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Implementation and evaluation of a mainframe dependent program (NEC3) on a Personal Computer (PC)

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THESIS

IMPLEMENTATION AND EVALUATION OF A
MAINFRAME DEPENDENT PROGRAM
(NEC3) ON A PERSONAL COMPUTER (PC)

by

Timothy M. O'Hara

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Thesis Advisor: R.W. Adler

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9 Abstract *(continue on reverse if necessary and identify by block number)*

The purpose of this study was to determine if recent improvements in the computing power of Personal Computers (PCs) have made them a viable alternative to the larger, multi-user oriented computers, better known as mainframes. The Numerical Electromagnetics Code (NEC3), a 10,000 line Fortran program, was down-loaded from the Naval Postgraduate School's IBM 3033AP mainframe and implemented on various PC systems. The systems considered were the IBM RT PC (using IBM RT PC VS FORTRAN), a Definicon DSI-780 Coprocessor Board (using SVS FORTRAN), and a Compaq Deskpro 386/20 AT PC (using NDP FORTRAN-386). Using NEC3 example problems, comparisions of speed and accuracy were made between the PCs and the mainframe.

Results show that the Compaq Deskpro 386/20, with a Weitek 1167 math coprocessor, using MicroWay's NDP FORTRAN-386 (32 bit Fortran compiler), can be used to implement NEC3 on a PC. Performance times for the Deskpro (w/1167) were only 20% to 25% slower than the mainframe's. Due to the Weitek's internal accuracy (single precision), solutions of the NEC3 examples were comparable to the mainframe's only for simple problems. As the complexity of the NEC3 problems increased, the error due to the Weitek's single precision calculations also increased.

It is assumed that the reader is currently knowledgable on the use of an IBM AT PC or compatible and that the reader is familiar with the PC's Disk Operating System (DOS).

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Implementation and Evaluation of a Mainframe Dependent Program (NEC3) on a Personal Computer (PC)

by

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ABSTRACT

The purpose of this study was to determine if recent improvements in the computing power of Personal Computers (PCs) have made them a viable alternative to the larger, multi-user oriented computers, better known as mainframes. The Numerical Electromagnetics Code (NEC3), a 10,000 line Fortran program, was down-loaded from the Naval Postgraduate School's IBM 3033AP mainframe and implemented on various PC systems. The systems considered were the IBM RT PC (using IBM RT PC VS FORTRAN), a Definicon DSI-780 Coprocessor Board (using SVS FORTRAN), and a Compaq Deskpro 386/20 AT PC (using NDP FORTRAN-386). Using NEC3 example problems, comparisions of speed and accuracy were made between the PCs and the mainframe.

Results show that the Compaq Deskpro 386/20, with a Weitek 1167 math coprocessor, using MicroWay's NDP FORTRAN-386 (32 bit Fortran compiler), can be used to implement NEC3 on a PC. Performance times for the Deskpro (w/1167) were only 20% to 25% slower than the mainframe's. Due to the Weitek's internal accuracy (single precision), solutions of the NEC3 examples were comparable to the mainframe's only for simple problems. As the complexity of the NEC3 problems increased, the error due to the Weitek's single precision calculations also increased.

It is assumed that the reader is currently knowledgable on the use of an IBM AT PC or compatible and that the reader is familiar with the PC's Disk Operating System (DOS).

THESIS DISCLAIMER

The reader is cautioned that computer programs developed in this research may not have been exercised for all cases of interest. While every effort has been made, within the time available, to ensure that the programs are free of computational and logic errors, they cannot be considered validated. Any application of these programs without additional verification is at the risk of the user.

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I. INTRODUCTION

A. PURPOSE

Within the last few years, the scientific, industrial, and educational communities have become increasingly dependent on the use of Personal Computers (PCs). Although word processing, data base management, and other utility programs have fueled this PC explosion, recent increases in CPU (Central Processing Unit) clock speeds and the improvement of math coprocessors have increased the computational capabilities of PCs to impressive levels. These improvements now make the PCs capable of handling numerically intensive programs usually reserved for larger computer systems, often referred to as mainframes.

The objective of this Thesis was to determine whether or not a large mainframe dependent program, specifically the Numerical Electromagnetics Code (NEC3), can be implemented on a PC. The PC systems to be considered are an IBM RT PC (work station), a Definicon DSI-780 Coprocessor Board (mounted in an IBM compatible AT/386), and a Compaq Deskpro 386/20 AT PC (with Intel 80387 and Weitek 1167 math coprocessors).[1]

B. BACKGROUND

NEC was originally developed at Lawrence Livermore National Laboratory, Livermore, California, under the sponsorship of the Naval Ocean System Center and Air Force Weapons Laboratory. This program is an offspring of the Antenna Modeling Program (AMP) written in the early 1970's by MBAssociates for the Naval Research Laboratory, Naval Ship Engineering Center, U.S. Army ECOM/Communication Systems, U.S. Army Strategic Communications Command, and Rome Air Development under the Naval Research Contract N00014-71-C-0187. NEC3, the current version of NEC, was developed by G.J. Burke of Lawrence Livermore Laboratory. [Ref. 1]

NEC3 is an antenna modeling program designed to handle a wide range of antenna structures. This makes it ideal for use in the military due to the numerous structures (e.g., ships and vehicles) used to support antennas. The code itself is heavily dependent

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1 IBM, IBM PC, IBM PC AT, and the IBM RT PC are trademarks of the International Business Machines Corporation. COMPAQ AND COMPAQ Deskpro 386/20 are trademarks of Compaq Computer Corporation. WEITEK 1167 is a trademark of the Weitek Corporation. DEFINICON and DSI-780 are trademarks of the Definicon Systems Incorporated.

on numerical integration and often pushes the computer's ability to calculate accurate data. NEC3, written in standard Fortran 77, is approximately 10,000 lines long and incorporates over 80 subroutines.

NEC was previously converted to a PC by Stephen P. Lamont. [Ref. 2] Each subroutine had to be separately compiled, and modifications to the code were made in order for NEC to run in the PC DOS (Disk Operating System) environment. Due to the limited in-core memory (640K), execution times were not fast enough to justify running NEC3 on a PC. However, recent advances in both hardware and software now make it worthwhile to investigate using a PC as an alternative to the mainframe.

C. CONTENTS

Chapter II describes hardware configurations for each of the three systems. Capabilities and limitations such as the 32 bit memory and the DOS 640K memory limit will be examined. Chapter II also lists and describes the software needed to compile, link, and execute NEC3 on all three systems.

Chapter III lists the software modifications that were necessary for NEC3 to be compiled and executed on each of the three systems. The compile time options are described to help future programmers escape many of the pitfalls encountered during this research.

Chapter IV includes the benchmarking and performance of each system based primarily on speed of calculations and determination of mantissa size. The benchmark programs used, WHETSTONE, BENCH, MANSIZE, and CMATVRT, are described, and the experimental results are analyzed. NEC3 sample problems were chosen to compare PC execution times and antenna input impedance solutions to those generated by the IBM 3033AP mainframe.

Chapter V lists the conclusions and recommendations prompted by the results of this research.

II. SYSTEM HARDWARE AND SOFTWARE CONFIGURATIONS

The computer systems used in this experiment include an IBM RT PC, a Definicon DSI-780 Coprocessor Board, a Compaq Deskpro 386/20 PC, and the Naval Postgraduate School's IBM 3033AP Mainframe. The IBM RT PC, Compaq Deskpro 386/20, and IBM 3033AP are fully independent computer systems. The DSI-780 however, does require the power supply and input/output (I/O) capabilities of an IBM AT PC compatible host. Each of these systems requires unique software in order to compile and execute Fortran programs such as NEC3 and SOMNTX.

Since the focus of this research is on the PC world, the hardware and software descriptions of the IBM 3033AP Mainframe will not be included. Performance times of the mainframe compared to the other systems will be detailed in Chapter IV.

A. IBM RT PC WORK STATION

The IBM RT PC is an advanced computing system. Operating under a version of UNIX, the IBM Advanced Interactive Executive Operating System (AIX), the RT PC is a multi-user and multi-tasking capable computer. It uses a 32 bit RISC (Reduced Instruction Set Chip) processor and a 40 bit virtual memory manager. The RT PC is available in various configurations; the system used for this research is a Model 125. It comes standard with an Advanced Processor Card, a NS32081 Floating Point Accelerator Card, 4 Mbytes of 32 bit memory, a 1.2 Mbyte floppy disk drive, and a 70 Mbyte fixed disk drive. Installed options include a second 70 Mbyte fixed disk drive, and a 360 Kbyte floppy disk drive. The monitor used is an IBM 6154 Advanced Color Graphics Display. [Ref. 3]

IBM RT PC VS FORTRAN is a powerful and rather extensive programming package. Some of the most important features include:

- Source compatibility with ANSI Standard FORTRAN 77.
- Optimized executable code.
- No significant limit on program or data size.
- Variety of compile time options.

The most important features required to compile and run NEC3 are standard FORTRAN 77 compatibility and the ability for virtually unlimited program or data size. The limiting factor for the program or data size is simply the amount of memory installed in the system. Because VS FORTRAN operates in the UNIX environment, the 640 Kbyte addressable memory limit that is encountered on most IBM PCs and compatibles does not occur. The larger available memory allows a program the size of NEC3, which has over 10,000 lines of source code and over 80 subroutines, to be compiled in one large program. The single program eliminates the need to individually compile and link each of the subroutines, thereby making the code more efficient. [Ref. 4]

The installation of VS FORTRAN on the RT PC is an automated function; however, Table 1 on page 5 lists the programs required to compile and execute source programs.

Table 1. IBM RT PC SYSTEM SOFTWARE COMPONENTS

Component	Disk File	Description
compiler	vsfort	the compiler module
assembler	vspass2 vspass3	the code generator the code formatter
linker	cc	the AIX linker
system utility	vsf vs	Script for invoking VS FORTRAN Script for invoking VS languages
libraries	libvssys.a libvsfor.a libvsfil.a libI77.a libF77.a	system run-time library FORTRAN run-time library FORTRAN AIX library f77 run-time library f77 intrinsic function library

The creation of executable code from source programs can be described in four steps:

1. Create program from text editor and store it with either .f or .for extension.
2. Compile source code to generate binary file (vs or vsf command).
3. Link binary files with AIX system files to make executable code (cc AIX command is performed automatically unless programmer specifically sets compile option to prevent linking.)
4. Run the program.

In practice the use of VS FORTRAN is relatively simple. The error messages are descriptive and useful. Once the source code has been debugged it is a simple matter to compile. link, and run programs written in Fortran. [Ref. 5]

B. DEFINICON DSI-780 COPROCESSOR BOARD

The Definicon Coprocessor is an accelerator board for the IBM PCs and compatibles. Available in various configurations, the model DSI-780 is used for this research. The significance of this model number is directly related to the board's computational performance. The 780 in the model number signifies that the DSI-780 emulates the capabilities of a VAX-780 computer. The DSI-780 is built around Motorola's MC68020 32 bit CPU, a 32 bit data bus, an MC68881 Floating Point Math Coprocessor, and 4

Mbytes of 32 bit dynamic RAM. The memory can be expanded to a maximum of 16 Mbytes with an upgrade to higher density chips. The DSI-780 system clock is a crystal oscillator running at 20 MHz with one wait state. To make the DSI-780 operational, the board must be installed in an IBM PC AT compatible expansion slot. Switch settings located on the DSI-780 must be set depending on the host PC's hardware configuration. The manual for the DSI-780 clearly describes the proper settings for the more common IBM PC compatibles. [Ref. 6]

The software required to compile and run a Fortran program on the DSI-780 Coprocessor has been listed in Table 2 below.

Table 2. DSI-780 SYSTEM SOFTWARE COMPONENTS

Component	Disk File	Description
compiler	FORTRAN.E20	the compiler module
assembler	JCODE.E20	the code generator
linker	LINK20.E20	the DSI linker
system utility	LOAD.EXE	the MS DOS program loader
libraries	FTNLIB.OBJ	standard FORTRAN 77 intrinsic functions
	PASLIB.OBJ	the pascal runtime library

The compiler, SVS FORTRAN (written by Silicon Valley Software, Cupertino, CA), was originally written for a UNIX operating system. SVS FORTRAN is a single pass compiler (i.e., only reads source code once) that compiles in two phases. During the first phase the code is broken into procedure-by-procedure parcels, and then the compiler writes the parcel's tree representation. This allows the compiler, during the second phase, to optimize each parcel separately, thereby resulting in code so efficient it cannot be further hand-optimized. These optimized parcels are combined with their tree information which results in machine code ready for conversion into an object file necessary for linking.

JCODE.E20 is the code generator (assembler) for the previously compiled Fortran machine code. Running the machine code through the JCODE generator results in object code ready for linking with the necessary libraries or separate subroutines. The code

generated by JCODE.E20, taken from the Motorola 68020 CPU instruction set, is in the final form necessary to execute on the DSI-780.

LINK20.E20 is the DSI linker that resolves all external calls and links the object modules with the required libraries. After linking, the original program can be loaded and executed using the DSI loader (LOAD.EXE).

LOAD.EXE is the PC DOS program loader which initializes and runs programs that have been compiled, assembled, and linked for the DSI-780. This loader does not physically load the program into the DSI-780 memory, but instead provides the address pointer of the program and initializes the DSI-780. Once initialized, the DSI-780 finds the program to be executed and uses its internal memory as needed. LOAD.EXE does provide the interface between the Host PC and the DSI-780 so I/O transfers can be accomplished.

C. COMPAQ DESKPRO 386/20

The Compaq Deskpro 386/20 (20 MHz clock) is one of the fastest and most powerful PCs available on the market today. Surpassed only by the Deskpro 386/25 (25 MHz clock), the Deskpro 386/20 is an IBM AT PC compatible system that uses an Intel 80386 32 bit CPU and Compaq's Flex Architecture for handling memory access. Available in various configurations, the Deskpro used in this research is a Model 60, and comes standard with an 80386-20 CPU, 1 Mbyte 32 bit memory, a 32 Kbyte cache memory, a 60 Mbyte fixed disk drive, a 1.2 Mbyte floppy disk drive, and accommodates both the Intel 80387 and the Weitek 1167 Math Coprocessors. Both coprocessors were installed for this research. Additional upgrade options installed include an additional 3 Mbytes of memory (total of 4 Mbytes), a Compaq VGA monitor, and a 1.4 Mbyte floppy disk drive. Memory can be expanded to a maximum of 16 Mbytes with appropriate hardware (higher density DRAMs). [Ref. 7]

Designed with 1 wait state for direct memory access, the Deskpro uses the Compaq Flexible Advanced Systems Architecture to reduce the delay caused by the wait state. Under normal operating conditions, Compaq claims that the 1 wait state is reduced to a 0 wait state 95% of the time. It accomplishes this by using a cache memory system in which the CPU gets its instuctions from a small (32 Kbyte) area of high speed (35 nsec) memory (cache). As long as the data needed by the CPU are in the cache, the processor will run with 0 wait states. If the data are not available, the CPU waits for the data to be retrieved from the slower system memory (DRAM). Installed math coprocessors also execute instructions from the cache memory. [Ref. 8]

The Intel 80387 is an 80 bit Math Coprocessor designed to support the 80386 CPU. It provides the CPU with the floating point performance necessary for numerically intensive applications. The Weitek WTL 1167 is a set of three chips mounted on a single PC board. It is designed to work with the 80386 CPU and provide floating point performance superior to that of the 80387. The Weitek 1167 board designed for use with the Compaq Deskpro PC includes a socket for the installation of the 80387, thereby allowing software to be compiled with either 80387 or Weitek instuctions. This convenient software option prompted the dual compilation and evaluation of NEC3 utilizing both the 80387 and the 1167 Math Coprocessors. [Ref. 9]

The software system used to compile, assemble, link, and run NEC3 on the Deskpro is a combination of two software packages: MicroWay's NDP FORTRAN-386 compiler (version 1.4e), and Phar Lap's Tools, containing the 386/ASM assembler (version 2.0), the 386/LINK linker (version 2.0), and the RUN386 DOS extender (version 2.0). NDP FORTRAN-386 is a UNIX based 32-bit Fortran compiler that generates assembly language code for the 80386 machines and supports the 80287, 80387, and Weitek 1167 Math Coprocessors. It requires a version of MSDOS 3.2 or higher, and at least 2 Mbytes of system memory. Although NDP does not require a coprocessor to compile source code, it does require one at run time. This compiler supports standard Fortran 77 and has a complete and thorough set of libraries. A list of the files required to compile, assemble, link, and run a Fortran program can be found in Table 3 on page 9. [Ref. 10]

Table 3. DESKPRO SYSTEM SOFTWARE COMPONENTS

Component	Disk File	Description
compiler	NDPF386.EXP	the compiler module
assembler	ASM386.EXE	assembler
linker	LINK386.EXE	linker
system utility	F77.EXE RUN386.EXE	compiler driver DOS extender
DOS interface modules	DOS386.OBJ CO387.OBJ CO1167.OBJ	run time module 80387 module Weitek 1167 module
libraries	LIBF.LIB LIBF1167.LIB LIBC.LIB LIBC1167.LIB LIBM.LIB LIBM1167.LIB LIBM287.LIB LIBM387.LIB LIBFGREX.LIB	FORTRAN support library FORTRAN support for 1167 C support (used by FORTRAN) C support for 1167 math library math library for 1167 math library for 80287 math library for 80387 extend graphics (FORTRAN)

The compiler and compiler driver (F77.EXE) have over 50 compile time options (switches) that can be set to control the creation of an executable program. Below is an example of this process using NEC3.

Example 1: Build NEC3.EXP with Weitek 1167 calls.

Create NEC3.f using a text editor (down loaded from Mainframe).

Create a batch file (MAKENEC3.bat) with the line:

```
WF77 %1.f -o %1 -v -n4 -OLM %2 %3 %4
```

This batch file will create NEC3.EXP by typing:

```
MAKENEC3 NEC3 second gettim
```

The actions generated during this procedure include:

COMPILING	NEC3.f -> NEC3.s
ASSEMBLING	NEC3.s -> NEC3.obj
LINKING	NEC3.obj,second.obj,gettim.obj,LIBM1167 -> NEC3.exp
DELETING	NEC3.s,NEC3.obj (saves disk space)

Table 4 on page 11 describes the options used in Example 1.

Table 4. NDP OPTIONS USED IN EXAMPLE 1.

Option	Description
-v	This option tells the compiler driver to print out the program names and command line arguments as it runs each subprocess. This switch proved helpful when compiling NEC3, as it provided the programmer with an occasional status report much desired for long compile times.
-o *filename*	This option places the executable file output into a file named *filename*. If *filename* is not specified the executable file will be named *a.out*.
-n4	This option instructs the compiler to generate code compatible with the Weitek 1167.
-OLM	Instructs compiler to perform maximum optimizations, to include speed optimizations related to moving code out of loops and speeding up loops in general, and additional memory optimizations.
Second and *gettim* are additional object modules used by NEC3 in order to retrieve the system time. *Second* is called from NEC3 but *second* in turn calls *gettim*. Replacing -n4 with the combination -n2 -n3 instructs the compiler to create executable code for the 80387 instead of the Weitek 1167.	

Once NEC3 is compiled, assembled, and linked, the Phar Lap RUN386.EXE program is still required to run NEC3. RUN386.EXE is a DOS extender that places the 80386 into the protected mode while running a program. Typing the following command: *RUN386 NEC3* executes NEC3. Since NDP FORTRAN-386 is based on the UNIX operating system, the only limit to the size of a program's arrays or storage space is the amount of memory installed in the PC. NEC3's in-core solution matrix was originally set to a 66 x 66 array; using NDP and the available system memory (4Mbytes), the solution matrix was increased to 300 x 300. This resulted in improved speed due to larger in-core memory access. [Ref. 10, 11]

III. COMPILATION OF NEC3 AND SOMNTX

Due to the differences between the various Fortran compilers used in this research, some modifications had to be made to the mainframe versions of NEC3 and SOMNTX source code. Most modifications were universal; however, some corrections were system (PC and compiler) dependent. The listings of modifications are broken down into two main groups, NEC3 and SOMNTX. Each group will be futher subdivided into universal and system (PC and compiler) specific modifications.

A. NEC3 MODIFICATIONS

No restructuring of the code was required to implement NEC3 on a PC. The modifications required were related to I/O specifics for each system and the calling of system time routines. Due to obsolete programming techniques, some data initialization had to be restructured.

1. Universal Modifications to NEC3

The most involved universal modification to NEC3 was the inclusion of the CHARACTER variable declaration. All character type data had to be redefined from type INTEGER to type CHARACTER. All mainframe dependent functions had to turned off or replaced with a PC substitute. Universal modifications made to NEC3 are detailed in Table 5 on page 13.

Table 5. UNIVERSAL MODIFICATIONS TO NEC3

Subroutine	Modifications
MAIN	Changes to variable declarations must be made as follows: CHARACTER*1 BLANK,SLASH CHARACTER*2 AIN,ATST(23) CHARACTER*6 HPOL(3),PNET(6) Delete line 183 (INTEGER*2 CARD(78) ...) Add to the data section: DATA BLANK/' '/,SLASH/'/'/ Comment out ERRSET mainframe function calls Lines 220,221,222
DATAGN	Changes to variable declarations: CHARACTER*1 IFX,IFY,IFZ,IPT CHARACTER*2 ATST,GM
NUMBER	Changes to variable declarations: CHARACTER*1 A(80),B(10),AMNUS,PLUS,POINT,EXP Delete lines 7392 (INTEGER A(80),B(10)/'0',...) and 7393 (INTEGER AMNUS/'-'/...) In data section add: DATA B/'0','1','2','3','4','5','6','7','8','9'/ DATA AMNUS/'-'/,PLUS/'+'/,POINT/'.'/,EXP/'E'/
PATCH	Remove the Hollerith formatting in line 7632 by replacing "62H" with "'"at begining and end of FORMAT statement.
RDPAT	Changes to variable declarations: CHARACTER*6 IGNTP,IGAX,IGTP,HCIR,HPOL,HBLK, CHARACTER*6 ISENS,HCLIF
READ	Changes to variable declarations: CHARACTER*1 A(80),BLANK,COMMA CHARACTER*2 AA Delete line 8176 (INTEGER AA,A(80),BLANK/' '/...) In data section add: DATA BLANK/' '/,COMMA/','/
PRNT	Changes to variable declarations: CHARACTER*4 HALL CHARACTER*6 IFORM,IVAR Change subroutine variable ICHAR to JCHAR, then change HALL in line 9804 to ICHAR(HALL)

2. IBM RT PC System-Specific Modifications to NEC3

Specific modifications on NEC3 for the RT PC using RT PC VS FORTRAN are relatively minor. The mainframe timer must be replaced with an RT PC equivalent, called TIME, and DREAL must be replaced with REAL. The necessity to replace DREAL is not logical; it can only be explained as a bug in the version of VS FORTRAN used in this research. A listing of system specific modifications can be found in Table 6 on page 14 below.

Table 6. IBM RT PC SYSTEM-SPECIFIC MODIFICATIONS TO NEC3

Subroutine	Modifications
ALL	If output file is desired all print statements can be replaced with WRITE(N,FOR): N = unit number FOR = line number for corresponding format statement
MAIN and FACIO	Replace XTIME with RT system timer TIME. Note: TIME is of data type INTEGER while XTIME is of type REAL therefore all variables relating to the time must be declared as INTEGER and the FORMAT statements must be modified accordingly.
LFACTR	Replace DREAL with DBLE.

3. DSI-780 System-Specific Modifications to NEC3

System specific modifications to NEC3 for the DSI-780 using SVS FORTRAN consist of replacing the mainframe timer with a DSI-780 system's equivalent, and opening files for the input and output of data. These modifications are listed in Table 7 below.

Table 7. DSI-780 SYSTEM-SPECIFIC MODIFICATIONS TO NEC3

Subroutine	Modifications
MAIN	Add subroutine INPUT (Appendix B) to NEC3 Place CALL INPUT command just before call to to TIMER
MAIN and FACIO	Replace timer XTIME by: 1. Add subroutine TIMER (Appendix A) to NEC3 2. Replace a typical XTIME call, SETIME = XTIME(DUMMY) with CALL TIMER(SETIME)

4. Deskpro System-Specific Modifications to NEC3

The system specific modification to NEC3 using NDP FORTRAN was simply replacing the mainframe timer with a NDP FORTRAN equivalent. The steps required for this modification are listed in Table 8 below.

Table 8. DESKPRO SYSTEM-SPECIFIC MODIFICATIONS TO NEC3

Subroutine	Modifications
MAIN and FACIO	Replace timer XTIME by using NDP function SECOND as shown in the following example: Change: SECOND = XTIME(DUMMY) To: ISETIME = SECOND(IDUMMY) SETIME = DBLE(ISETIME)/100.

B. SOMNTX MODIFICATIONS

Modifications to SOMNTX are minor, relating to data initialization and the invocation of system time calls. A method to input initialization data for SOMNTX must be selected. The current mainframe version reads UNIT=21 for input data. Listed in the tables below are the universal and system specific modifications to SOMNTX.

1. Universal Modifications to SOMNTX

The only universal modification needed for SOMNTX is the addition of three COMMON areas as listed in Table 9. This was required due to poor programming practices in the data initialization techniques.

Table 9. SOMNTX UNIVERSAL MODIFICATIONS

Subroutine	Modifications
BESSEL	Add the following to BESSEL COMMON area: COMMON /BESSAV/ M,A1,A2
HANKEL	Add the following to HANKEL COMMON area: COMMON /HANSAV/ M,A1,A2,A3,A4
EVLUB	Add the following to HANKEL COMMON area: COMMON /EVLSAV/ CK1R,CK1I,CK2R,CK2I,CP1,CP2,CP3

2. IBM RT PC System-Specific Modifications to SOMNTX

The only modification required to SOMNTX for the RT PC with RT PC VS FORTRAN was the replacement of the mainframe timer with an RT PC equivalent. The procedure is listed in Table 10 below.

Table 10. IBM RT PC SYSTEM-SPECIFIC MODIFICATIONS TO SOMNTX

Subroutine	Modifications
MAIN and SOMLSQ and SOMTRP	Replace XTIME with RT system timer TIME. Note: TIME is of data type INTEGER while XTIME is of type REAL, therefore all variables relating to the time must be declared as INTEGER and the FORMAT statements must be modified accordingly.
SOMNTX requires 3 input parameters. The mainframe version has SOMNTX read a file of type [FILE.FT05F001] for the input parameter. The RT PC does support this file structure.	

3. DSI-780 System-Specific Modifications to SOMNTX

System specific modifications to SOMNTX for the DSI-780 using SVS FORTRAN consisted of opening the output file and replacing the mainframe timer with the SVS FORTRAN equivalent. These modifications are listed in Table 11 below.

Table 11. DSI-780 SYSTEM-SPECIFIC MODIFICATIONS TO SOMNTX

Subroutine	Modifications
MAIN	Add OPEN statement to MAIN immediately after IFLN=21 OPEN(IFLN,FILE='SOMNTX.DAT')
MAIN and SOMLSQ and SOMTRP	Replace timer XTIME by: 1. Add subroutine TIMER (Appendix A) to NEC3 2. Replace a typical XTIME call, SETIME = XTIME(DUMMY) with CALL TIMER(SETIME)

4. Deskpro System-Specific Modifications to SOMNTX

System specific modifications to SOMNTX on the Deskpro 386/20 using NDP FORTRAN were identical to those used on the DSI-780 system. Although opening an output file in not required (NDP FORTRAN will assign a temporary file), it is suggested a specific file name be assigned for file management flexibility. These modifications are listed in Table 12 below.

Table 12. DESKPRO SYSTEM-SPECIFIC MODIFICATIONS TO SOMNTX

Subroutine	Modifications
MAIN	Add OPEN statement to MAIN immediately after IFLN=21 OPEN(IFLN,FILE='SOMNTX.DAT')
MAIN and SOMLSQ and SOMTRP	Replace timer XTIME by using NDP function SECOND as shown in the following example: Change: SECOND = XTIME(DUMMY) To: ISETIME = SECOND(IDUMMY) SETIME = DBLE(ISETIME)/100.

C. COMPILE TIME OPTIONS

1. Compile Time Options for the RT PC VS FORTRAN

NEC3 was compiled on the RT PC with the default options. [Ref. 4]

2. Compile Time Options for the SVS FORTRAN (DSI-780)

NEC3 was compiled on the DSI-780 with the SVS FORTAN default options which include the maximum optimization. [Ref. 6]

3. Compile Time Options for the NDP FORTRAN 77 (Deskpro 386/20)

```
-n2 -n3   - These options instruct the compiler to generate
            optimized code for the 80387 coprocessor. When -n3
            is used -n2 must also be included.

-n4       - This option instructs the compiler to generate
            optimized code for the Weitek 1167.

-OLM      - Instructs the compiler that maximum optimization
            is required.
```

A complete and thorough description of these options can be found in the NDP User's Manual. [Ref. 10]

IV. BENCHMARK AND PERFORMANCE

A. BENCHMARKS

Benchmarks are programs written to help quantify a computer's performance and to rate that performance against that of other computers. This allows programmers to evaluate the strengths of one computer over those of another. Each Benchmark is written to test some capability of the PC; some examples include:

- read/write to memory
- read/write to disk
- multiplications/divisions
- additions/subtractions
- iterative loop efficiencies

The procedure for using a benchmark can be summarized as follows:

1. Take the source code for a desired Benchmark and compile it on the computer being tested.
2. Repeat step 1. for all computers being evaluated.
3. Consolidate Benchmark results and draw conclusions.

The choice of which Benchmark to use depends on what type of operations the computer evaluator wants tested. The Benchmarks used in this experiment are the WHETSTONE, BENCH, MANSIZE, and CMATVRT. Of the four Benchmarks, WHETSTONE is the only program not written by Naval Postgraduate School personnel.

For each of the benchmarks, performance ratings will be described in terms of percentages. This percentage will relate the PC's performance to the mainframe's. For example, a 50% performance rating would indicate that the PC was running at half the mainframe capability. In this manner, the PC systems being evaluated can easily be compared to each other and to the mainframe.

1. WHETSTONE

The WHETSTONE benchmark can best be thought of as a program that measures the time required to do an average simple operation in the simplest manner. There are two versions of WHETSTONE used in this research, one in single precision and one in double precision. The output is presented in units of a thousand WHETSTONE operations per second (Kflop) and has been compiled in Table 13.

Performance ratings of the RT PC and DSI-780 range between 22% to 29%, indicating that the 3033AP runs approximately 4 times faster. The Deskpro 386/20 (w80387) tested 45% to 51%, while the Deskpro (w/1167) showed the best performance with an 80% performance rating.

A copy of the WHETSTONE source code is located in Appendix A.

Table 13. WHETSTONE BENCHMARK: WHETSTONE Single and Double Precision Results (Kflop)

System	Single Whetstone (Kflop)	Double Whetstone (Kflop)
IBM RT PC	909	870
DSI-780	1000	973
Deskpro 386/20 (w/80387)	1838	1725
Deskpro 386/20 (w/1167)	3280	2677
IBM 3033AP (mainframe)	4076	3386

2. BENCH

BENCH was written by Prof. J. Breakall, Naval Postgraduate School, and is designed to test a computer's ability to perform a selection of typical computations (tasks) often encountered in engineering type programs. These tasks include:

- DO LOOPS
- INTEGER ADDITIONS
- INTEGER MULTIPLICATIONS
- REAL ADDITIONS
- REAL MULTIPLICATIONS

Each iteration was repeated 1,000,000 times. Due to the DO LOOP iterations, all optimization must be turned off when compiling this benchmark. BENCH results give the Deskpro (w/1167) a rating of 43%, which makes it the closest competitor to the 3033AP. All performance ratings are almost two times lower than the WHETSTONE results, indicating the the adverse effect of turning off all optimizations. The results are listed in Table 14 below.

Table 14. BENCH BENCHMARK: Computation times for various calculations (Sec)

System	BENCH 1,000,000 iterations (seconds)
IBM RT PC	32.17
DSI-780	15.17
Deskpro 386/20 (w/80387)	12.88
Deskpro 386/20 (w/1167)	5.08
IBM 3033AP (mainframe)	2.20

3. MANSIZE

MANSIZE is a program designed to determine the number of bits a computer uses in calculating the mantissa, and to determine the smallest number the computer can represent. This benchmark was chosen due to the accuracy needs of both NEC3 and SOMNTX. Results of this test are listed in Table 15. A copy of the MANSIZE source code is located in Appendix C.

Table 15. MANSIZE BENCHMARK: Size of Calculated Mantissa and Smallest Representable Number.

System	Mantissa Length (bits)	Smallest Representable Number
IBM RT PC	23	1.401298E-45
DSI-780	63	1.401298E-45
Deskpro 386/20 (w/80387)	63	1.401300E-45
Deskpro 386/20 (w/1167)	23	1.175490E-39
* IBM 3033AP (mainframe)	52	0.539761E-78
* MANSIZE compiled in double precision.		

It should be noted that the mantissa length of 23 bits for the Weitek 1167 is somewhat disappointing. The speed benefits from the Weitek are shadowed by the lack of precision. Double precision MANSIZE results in a 53 bit mantissa for the Weitek 1167, but a loss in speed results. MANSIZE was calculated in double precision for the IBM 3033AP because of the compile time option which converted NEC3 from single precision to double precision. Single precision MANSIZE for the IBM 3033AP resulted in a mantissa length of 20.

4. CMATVRT

CMATVRT is a Fortran program written by Prof. M. Morgan of the Naval Postgraduate School; it initializes and inverts a complex matrix of selectable size. This benchmark reflects the degree of matrix computations used in NEC3 and SOMNTX.

The results show significantly higher ratings for the Deskpro systems, 27% for the 80387 and 86% for the Weitek 1167, compared to the RT PC's and the DSI-780's ratings of 6%. Due to NEC3's dependence on matrix calculations, these results indicate that, of the PC systems being evaluated, the Deskpro's systems will implement NEC3 more efficiently. Results are compiled in Table 16.

A copy of the Fortran source code is located in Appendix D.

Table 16. CMATVRT BENCHMARK: Complex Matrix Inverter

System	Fill Time (Seconds)	Inversion Time (Seconds)	Total Time (Seconds)
IBM RT PC	176	513	1196
DSI-780	173.95	510.80	1217.97
Deskpro 386/20 (w/ 80387)	39.76	123.53	300.45
Deskpro 386/20 (w/ 1167)	12.36	34.88	85.41
IBM 3033AP (mainframe)	10.58	30.03	73.70

At this point it must be realized that the real question to be answered in this research is how each of the systems under consideration performs when executing the NEC3 program. These benchmarks were included to give added insight to each system's capabilities, and to defend the results from the NEC3 sample runs.

B. PERFORMANCE RESULTS OF NEC3 SAMPLE RUNS

The examples used to evaluate NEC3 are by no means a complete representation of the types of antenna design problems that can be implemented on NEC3. However, these examples do represent a wide range of antenna problems and are considered a good test bed in the evaluation of NEC3. Below are the performance results for each of the chosen examples. [Ref. 12]

It should be noted that the input impedances generated on NEC3 using the Deskpro 386/20 (w/80387) and NDP FORTRAN-386 appear to be random. Although this randomness is not seen in the example G2.NEC, it does become apparent in S5.NEC, RHOMBIC.NEC, and all the Dipole examples. For simple antenna designs (e.g., G2.NEC), the Deskpro (w/80387) produces non-random results. However, as the designs increase in compexity the randomness begins to appear in the solutions. Either through faults in the software or the 80387 or both, the solutions of the dipoles' input impedances do vary from run to run. These example problems were repeated on an identically configured Deskpro 386/20 with the same results. Although the answers appear to approximate the 3033AP results, the solutions can not be validated. The numbers that appear in the following tables for the Deskpro (w/80387) are averages of several runs using identical input files.

1. S5.NEC - 12 Element Log-Periodic Antenna in Free Space.

Results of this example show that the Deskpro (w 1167), with a rating of 47%, has the best performance. Input impedances for all PC systems are equal and closely approximate the 3033AP's solution. Result are listed in Table 17 below.

Table 17. **EXAMPLE S5.NEC:** Log-Periodic Antenna

System	Fill Time (Seconds)	Factor Time (Seconds)	Total Time (Seconds)
IBM RT PC	89	24	179
DSI-780	82.42	24.7	163.00
Deskpro 386/20 (w/80387)	27.95	4.73	51.90
Deskpro 386/20 (w/1167)	11.42	1.65	20.55
IBM 3033AP (mainframe)	5.34	1.06	9.62

System	Input Impedance (Ohms)	Gain (dB)
IBM RT PC	42.33 - j0.45	9.75
DSI-780	42.33 - j0.45	9.75
* Deskpro 386/20 (w/80387)	42.33 - j0.45	9.75
Deskpro 386/20 (w/1167)	42.33 - j0.45	9.75
IBM 3033AP (mainframe)	42.45 - j0.80	9.76

* Because of the randomness of the system, the reported results are the averages of several solutions.

2. G2.NEC - Monopole Antenna on a Ground Stake (requires SOMNTX data)

Performance ratings for this example again indicate the superior speed of the Deskpro (w/Weitek). However, the input impedance could not be calculated for the Weitek due to a precision related run time error. All other input impedances closely resemble the 3033AP's solution. Results are listed in Table 18 below.

Table 18. **EXAMPLE G2.NEC:** Monopole on a ground stake (requires SOMNTX data)

System	Fill Time (Seconds)	Factor Time (Seconds)	Total Time (Seconds)
IBM RT PC	60	< 1	98
DSI-780	56.30	0.33	88.86
Deskpro 386/20 (w/80387)	13.62	0.11	23.50
Deskpro 386/20 (w/1167)	6.02	0.02	11.21
IBM 3033AP (mainframe)	3.25	0.003	4.99
System	**Input Impedance (Ohms)**		**Gain (dB)**
IBM RT PC	96.78 + j38.35		0.32
DSI-780	96.55 + j38.71		0.32
Deskpro 386/20 (w/80387)	96.78 + j38.36		0.32
Deskpro 386/20 (w/1167)	Note		0.32
IBM 3033AP (mainframe)	94.88 + j39.01		0.33

3. RHOMBIC.NEC - Rhombic Antenna Horizontally Polarized.

Results from the Rhombic example closely correspond to the previous examples of NEC3. Again, the Deskpro systems displayed superior speed while maintaining good solutions for the input impedances. With a performance rating of 47%, the Deskpro (w/1167), is consistently twice as slow as the 3033AP mainframe. Results are listed in Table 19 below.

Table 19. EXAMPLE RHOMBIC.NEC: Rhombic Antenna Horizontally Polarized

System	Fill Time (Seconds)	Factor Time (Seconds)	Total Time (Seconds)
IBM RT PC	260	51	391
DSI-780	244.91	53.23	359.88
Deskpro 386/20 (w/80387)	65.03	10.17	99.15
Deskpro 386/20 (w/1167)	25.54	3.62	38.34
IBM 3033AP (mainframe)	11.87	2.42	17.98
System	**Input Impedance (Ohms)**		**Gain (dB)**
IBM RT PC	352.05 + j172.06		17.95
DSI-780	352.06 + j172.06		17.95
* Deskpro 386/20 (w/80387)	352.32 + j172.14		17.95
Deskpro 386/20 (w/1167)	352.05 + j172.00		17.95
IBM 3033AP (mainframe)	352.05 + j172.04		17.95

* Because of the randomness of the system, the reported results are the averages of several solutions.

4. DIP49.NEC - Dipole Evaluated with 49 Segments

Performance results range from 7% for the PC RT to 59% for the Deskpro (w/1167). All solutions for the input impedance closely resemble the 3033AP solution. Results are listed in Table 20 below.

Table 20. **EXAMPLE DIP49.NEC:** Dipole Evaluated with 49 Segments

System	Fill Time (Seconds)	Factor Time (Seconds)	Total Time (Seconds)
IBM RT PC	40	6	50
DSI-780	36.91	6.15	44.60
Deskpro 386/20 (w/80387)	12.41	1.04	14.11
Deskpro 386/20 (w/1167)	5.08	0.45	5.88
IBM 3033AP (mainframe)	3.01	0.24	3.46

System	Input Impedance (Ohms)	Power (Watts)
IBM RT PC	78.01 + j45.52	4.78E-02
DSI-780	77.90 + j44.36	4.85E-02
* Deskpro 386/20 (w/80387)	78.02 + j45.87	4.76E-03
Deskpro 386/20 (w/1167)	77.91 + j43.66	4.88E-03
IBM 3033AP (mainframe)	77.90 + j44.48	4.84E-03

* Because of the randomness of the system, the reported results are the averages of several solutions.

5. DIP99.NEC - Dipole Evaluated with 99 Segments

Results of this example begin to show the effect of the Weitek's 23 bit mantissa. Although the performance rating for the Deskpro (w/1167) is excellent (67%), the solution of the dipole's input impedance is beginning to deviate from that of the 3033AP's. The Deskpro using the 80387 has a 63 bit mantissa and performance rating of of 27%. Results are listed in Table 21 below.

Table 21. EXAMPLE DIP99.NEC: Dipole Evaluated with 99 Segments

System	Fill Time (Seconds)	Factor Time (Seconds)	Total Time (Seconds)
IBM RT PC	154	48	207
DSI-780	142.80	50.67	197.07
Deskpro 386/20 (w/80387)	48.23	9.72	59.43
Deskpro 386/20 (w/1167)	19.72	3.57	23.95
IBM 3033AP (mainframe)	12.25	2.24	14.81
System	**Input Impedance (Ohms)**		**Power (watts)**
IBM RT PC	79.625+ j71.703		3.47E-03
DSI-780	80.169+ j86.23		2.89E-03
* Deskpro 386/20 (w/80387)	79.03 + j60.65		3.98E-03
Deskpro 386/20 (w/1167)	77.38+ j31.51		5.54E-03
IBM 3033AP (mainframe)	78.00 + j44.61		4.83E-03

* Because of the randomness of the system, the reported results are the averages of several solutions.

6. DIP199.NEC - Dipole Evaluated with 199 Segments

Although the performance ratings are consistent with the other examples, only the Deskpro with the 80387 is still maintaining an input impedance solution resembling that of the 3033AP's. The Weitek input impedance solution is no longer valid. Results are listed in Table 22 below.

Table 22. EXAMPLE DIP199.NEC: Dipole Evaluated with 199 Segments

System	Fill Time (Seconds)	Factor Time (Seconds)	Total Time (Seconds)
IBM RT PC	600	389	1005
DSI-780	556.00	619.81	1190.03
* Deskpro 386/20 (w/80387)	185.60	78.92	269.03
Deskpro 386/20 (w/1167)	75.74	28.95	106.28
IBM 3033AP (mainframe)	51.82	19.00	71.68
System	**Input Impedance (Ohms)**		**Power (Watts)**
IBM RT PC	134.85 + j80.941		1.00E-03
DSI-780	69.63 - j135.12		1.50E-03
* Deskpro 386/20 (w/80387)	77.00 + j42.54		5.18E-03
Deskpro 386/20 (w/1167)	94.99 + j273.73		5.66E-04
IBM 3033AP (mainframe)	78.05 + j44.69		4.82E-03

* Because of the randomness of the system, the reported results are the averages of several solutions.

7. DIP299.NEC - Dipole Evaluated with 299 Segments

The evaluation of a 299 segment dipole clearly shows the high precision requirements of the NEC3 code. Only the Deskpro (w/80387) system can maintain a solution comparable with that of the 3033AP's. With a performance rating of 28%, the Deskpro (w/80387) is almost 4 times as slow as the 3033AP mainframe. Results are listed in Table 23 below.

Table 23. EXAMPLE DIP299.NEC: Dipole Evaluated with 299 Segments

System	Fill Time (Seconds)	Factor Time (Seconds)	Total Time (Seconds)
IBM RT PC	1338	1319	2689
DSI-780	1239.72	1380.40	2644.50
* Deskpro 386/20 (w/80387)	411.28	269.13	689.48
Deskpro 386/20 (w/1167)	168.29	97.34	269.68
IBM 3033AP (mainframe)	121.69	67.36	190.73

System	Input Impedance (Ohms)	Power (Watts)
IBM RT PC	143.68 - j394.42	4.60E-06
DSI-780	42.75 - j2152.3	4.60E-06
* Deskpro 386/20 (w/80387)	81.95 + j52.95	3.33E-05
Deskpro 386/20 (w/1167)	30.165 - j1923.5	4.10E-06
IBM 3033AP (mainframe)	78.08 + j44.72	4.82E-03

* Because of the randomness of the system, the reported results are the averages of several solutions.

Appendices G, H, I, J, and K contain the output files generated with the selection of examples above for the IBM RT PC, the DSI-780 the Deskpro 386/20 (w/80387), the Deskpro 386/20 (w/1167), and the IBM 3033AP Mainframe respectively.

V. CONCLUSIONS

The results of the testing clearly show that the PC is now a viable option to the mainframe when implementing large engineering programs. Of the three systems reviewed, it is clear that the Compaq DESKPRO 386/20 was the fastest and most powerful machine.

The Deskpro, when using the Weitek 1167 math coprocessor, was approximately 50% to 75% faster than all other systems. The Whetstone benchmark results indicate that only 20% of the Weitek's speed advantage is lost when calculations are made in double precision. The Deskpro 386/20 and 1167 combination rated between 75% and 80% of the IBM 3033AP mainframe. The disadvantage for the Weitek is its 23 bit mantissa instead of the 80387's 63 bit mantissa. This loss of accuracy was evident in the dipole examples of the previous chapter. As the number of segments increase, the amount of accuracy required by NEC3 also increases, requiring increased resolution in the NEC3 generated output. It it therefore recommended the NEC3 code be converted to double precision and re-evaluated. NEC3, converted to double precision, should improve the Weitek solution while still allowing a speed advantage over the 80387.

The Deskpro when using the 80387 math coprocessor, rated between 20% and 25% of the IBM 3033AP mainframe. The accuracy of the 80387 is much better than the Weitek's, and thereby better suited for NEC3 problems. This accuracy is overshadowed by the fact that the NDP FORTRAN/80387 combination results in unstable code that creates NDP FORTRAN "exception" flags during runs. These shortcomings must be further investigated to uncover and correct NDP FORTRAN bugs and to determine if the 80387 and/or NDP FORTRAN is flawed.

The run times produced by the 3033AP are true processor times without the obvious overhead (e.g., disk read/writes and time sharing) added to it. It is often during peak usage of the mainframe that this overhead can become substantial and result in long delays not inherent in the PC world.

It should also be noted that due to the unstable results of the Deskpro (w/80387), separate tests of the dipole examples were run on a version of NEC3 that was compiled for an IBM AT using a 80287 Math Coprocessor with MS FORTRAN (version 4.01). These tests resulted in input impedances which closely resembled those calculated with the IBM 3033AP. Due to these good results using a 16 bit Fortran compiler, it seems

that the 32 bit UNIX FORTRANs still need some refinement. The results of this research indicate that the true potential for these 32 bit Fortrans in implementing large numerically intensive programs is excellent. Additional implementations of NEC3 with other 32 bit Fortrans, such as Silicon Valley Software's SVS FORTRAN 386 and Lahey Computer Systems' F77L-EM/32, should be attempted.

A numerical analysis to evaluate the necessary word lengths for NEC3 and SOMNTX for implementation on a PC should be performed. This analysis should find the critical computations that need 53 bits and convert only these to Complex *16 for use with the Deskpro (w/Weitek 1167). This allows the speed advantage of the Weitek code to be only slightly reduced.

Of the three PC systems evaluated, only the Deskpro 386/20 provided enough speed and accuracy to challenge the mainframe. The Deskpro (w/Weitek 1167) is the fastest, but modifications to NEC3 must be made to minimize the Weitek's loss of accuracy. The Deskpro (w/80387) is slower, but provides increased accuracy. This conclusion assumes that the bug that is causing the 80387 pseudo-random solutions is correctable.

APPENDIX A. TIMER SUBROUTINE FOR DSI-780

```
C
C     TIMER - RETURNS THE SYSTEM TIME IN SECONDS WHEN USING THE
C             DSI-780, AND SVS FORTRAN.
C     WRITTEN BY TIMOTHY M. O'HARA
C     NAVAL POSTGRADUATE SCHOOL
C     MONTEREY CA, 1988
C
      SUBROUTINE TIMER(TIME)
      CALL GTIME(ITIME)
      IHOUR =ISHFT(ITIME,-24)
      IMIN  =ISHFT(IAND(16711680,ITIME),-16)
      ISEC  =ISHFT(IAND(65280,ITIME),-8)
      IMSEC =IAND(255,ITIME)
      TIME =(IHOUR*60.*60.+IMIN*60.+ISEC*1.+IMSEC/100.)
      RETURN
      END
```

APPENDIX B. INPUT SUBROUTINE FOR DSI-780

```
C
C     INPUT - OPENS THE NECESSARY FILES NEEDED FOR NEC3. IT PROMPTS
C             THE USER FOR INPUT AND OUTPUT FILE NAMES. THIS SUBROUTINE
C             WAS REQUIRED FOR THE DSI-780 USING SVS FORTRAN.
C
C     WRITTEN BY TIMOTHY M. OHARA
C                NAVAL POSTGRADUATE SCHOOL
C                MONTERY CA.,   1988
C
      SUBROUTINE INPUT
      CHARACTER*14 IN,OUT,SOMFLD,PLOT
      WRITE (*,100)
      READ  (*,200) IN
      WRITE (*,105)
      READ  (*,200) OUT
      WRITE (*,110)
      READ  (*,200) PLOT
      WRITE (*,115)
      READ  (*,200) SOMFLD
      OPEN  (3,FILE=IN,STATUS='OLD')
      OPEN  (0,FILE=OUT,STATUS='NEW')
      OPEN  (8,FILE=PLOT,STATUS='NEW')
      OPEN  (11,FORM='UNFORMATTED',STATUS='SCRATCH')
      OPEN  (12,FORM='UNFORMATTED',STATUS='SCRATCH')
      OPEN  (13,FORM='UNFORMATTED',STATUS='SCRATCH')
      OPEN  (14,FORM='UNFORMATTED',STATUS='SCRATCH')
      OPEN  (15,FORM='UNFORMATTED',STATUS='SCRATCH')
      OPEN  (16,FORM='UNFORMATTED',STATUS='SCRATCH')
      OPEN  (20,FORM='UNFORMATTED',STATUS='SCRATCH')
      IF    (SOMFLD.EQ.'NA') GO TO 300
      IF    (SOMFLD.EQ.'na') GO TO 300
      OPEN  (21,FILE=SOMFLD,STATUS='OLD',FORM='UNFORMATTED')
100   FORMAT (' ENTER INPUT FILE NAME -> ',$)
105   FORMAT (' ENTER OUTPUT FILE NAME -> ',$)
110   FORMAT (' ENTER THE FILE NAME OF THE PLOT DATA FILE -> ',$)
115   FORMAT (' ENTER SOMMERFELD DATA FILE OR "NA" IF NOT NEEDED -> ',$)
200   FORMAT (A)
300   RETURN
      END
```

APPENDIX C. WHETSTONE BENCHMARK PROGRAM

```
C        WHETSTONE.FOR
C
C        DOUBLE-PRECISION VARIANT OF PROGRAM.
C
C        "WHETSTONE INSTRUCTIONS PER SECONDS" MEASURE OF FORTRAN
C        AND CPU PERFORMANCE.
C
C        SUBROUTINE TIMER ADDED FOR USE WITH DIFINICON DSI-780
C
       IMPLICIT REAL*8 (A-H,O-Z)
       REAL*4 TIME0,TIME1,TIMER
       COMMON T,T1,T2,E1(4),J,K,L
C
C        Set KFLAG = 0 to suppress printouts.
C        Set KFLAG = 1 to get a printout of section results.
C
       KFLAG = 0
C
C      Benchmark constants:
C      With loop set to 10, 1000000 Whetstone instructions
C      will be executed each time thru the DO loop.
C      The DO loop is executed iter times. This is done solely
C      for timing accuracy.
C      Note: If you change loop, you are not running the "Whetstone
C      benchmark". Increasing the value of iter will give
C      more accurate timings at the cost of longer elapsed
C      time to complete the benchmark.
C
        LOOP = 10
        ITER = 5
        T=0.499975D00
        T1=0.50025D00
        T2=2.0D00


C
C        ***** Start of Timed Interval *****
C
        CALL TIMER(TIME0)
C
        DO 200 JJ = 1,ITER
C
C        Establish relative loop counts for each module.
C
        N1=0
        N2=12*LOOP
        N3=14*LOOP
        N4=345*LOOP
        N5=0
        N6=210*LOOP
        N7=32*LOOP
```

```
      N8=899*LOOP
      N9=616*LOOP
      N10=0
      N11=93*LOOP
C
C     Simple identifiers.
C
      X1=1.0D0
      X2=-1.0D0
      X3=-1.0D0
      X4=-1.0D0
      IF(N1)19,19,11
 11   DO 18 I=1,N1,1
      X1=(X1+X2+X3-X4)*T
      X2=(X1+X2-X3+X4)*T
      X4=(-X1+X2+X3+X4)*T
      X3=(X1-X2+X3+X4)*T
 18   CONTINUE
 19   CONTINUE
      IF (KFLAG.EQ.JJ) CALL POUT(N1,N1,N1,X1,X2,X3,X4)
C
C     Array elements.
C
      E1(1)=1.0D0
      E1(2)=-1.0D0
      E1(3)=-1.0D0
      E1(4)=-1.0D0
      IF(N2)29,29,21
 21   DO 28 I=1,N2,1
      E1(1)=(E1(1)+E1(2)+E1(3)-E1(4))*T
      E1(2)=(E1(1)+E1(2)-E1(3)+E1(4))*T
      E1(3)=(E1(1)-E1(2)+E1(3)+E1(4))*T
      E1(4)=(-E1(1)+E1(2)+E1(3)+E1(4))*T
 28   CONTINUE
 29   CONTINUE
      IF (KFLAG.EQ.JJ) CALL POUT(N2,N3,N2,E1(1),E1(2),E1(3),E1(4))
C
C     Array as parameter.
C
      IF(N3)39,39,31
 31   DO 38 I=1,N3,1
 38   CALL PA(E1)
 39   CONTINUE
      IF (KFLAG.EQ.JJ) CALL POUT(N3,N2,N2,E1(1),E1(2),E1(3),E1(4))
C
C     Conditional jumps.
C
      J=1
      IF(N4)49,49,41
 41   DO 48 I=1,N4,1
      IF(J-1)43,42,43
 42   J=2
      GOTO44
 43   J=3
 44   IF(J-2)46,46,45
 45   J=0
```

```
      GOTO47
 46   J=1
 47   IF(J-1)411,412,412
 411  J=1
      GOTO48
 412  J=0
 48   CONTINUE
 49   CONTINUE
      IF (KFLAG.EQ.JJ) CALL POUT(N4,J,J,X1,X2,X3,X4)
C
C     Integer arithmetic.
C
      J=1
      K=2
      L=3
      IF(N6)69,69,61
 61   DO 68 I=1,N6,1
      J=J*(K-J)*(L-K)
      K=L*K-(L-J)*K
      L=(L-K)*(K+J)
      E1(L-1)=J+K+L
      E1(K-1)=J*K*L
 68   CONTINUE
 69   CONTINUE
      IF (KFLAG.EQ.JJ) CALL POUT(N6,J,K,E1(1),E1(2),E1(3),E1(4))
C
C     Trigonometric functions.
C
      X=0.5D0
      Y=0.5D0
      IF(N7)79,79,71
 71   DO 78 I=1,N7,1
      X=T*DATAN(T2*DSIN(X)*DCOS(X)/(DCOS(X+Y)+DCOS(X-Y)-1.0D0))
      Y=T*DATAN(T2*DSIN(Y)*DCOS(Y)/(DCOS(X+Y)+DCOS(X-Y)-1.0D0))
 78   CONTINUE
 79   CONTINUE
      IF (KFLAG.EQ.JJ) CALL POUT(N7,J,K,X,X,Y,Y)
C
C     Procedure calls.
C
      X=1.0D0
      Y=1.0D0
      Z=1.0D0
      IF(N8)89,89,81
 81   DO 88 I=1,N8,1
 88   CALL P3(X,Y,Z)
 89   CONTINUE
      IF (KFLAG.EQ.JJ) CALL POUT(N8,J,K,X,Y,Z,Z)
C
C     Array references.
C
      J=1
      K=2
      L=3
      E1(1)=1.0D0
      E1(2)=2.0D0
```

```
      E1(3)=3.0D0
      IF(N9)99,99,91
 91   DO 98 I=1,N9,1
 98   CALL P0
 99   CONTINUE
      IF (KFLAG.EQ.JJ) CALL POUT(N9,J,K,E1(1),E1(2),E1(3),E1(4))
C
C     Integer arithmetic.
C
      J=2
      K=3
      IF(N10)109,109,101
 101  DO 108 I=1,N10,1
      J=J+K
      K=J+K
      J=J-K
      K=K-J-J
 108  CONTINUE
 109  CONTINUE
      IF (KFLAG.EQ.JJ) CALL POUT(N10,J,K,X1,X2,X3,X4)
C
C     Standard functions.
C
      X=0.75D0
      IF(N11)119,119,111
 111  DO 118 I=1,N11,1
 118  X=DSQRT(DEXP(DLOG(X)/T1))
 119  CONTINUE
      IF (KFLAG.EQ.JJ) CALL POUT(N11,J,K,X,X,X,X)
200   CONTINUE

C
C     ****  End Of Timed Interval *****
C
      CALL TIMER(TIME1)
C
C     Performance in Whetstone KIP's per second is given by
C     Where time is in seconds.
C
      WHETS = (100.0 * DBLE(LOOP) * DBLE(ITER))/(TIME1-TIME0)
      WRITE (*,201) WHETS
201   FORMAT(/' Speed is ',D10.5,' Thousand Whetstone',
     2   ' Double Precision Instructions Per Second.')
      WRITE (*,202) INT((TIME1-TIME0)*100.0/DBLE(ITER))
202   FORMAT (' Single Pass Time = ',I5, ' Hundredths of a Second.')
      END

      SUBROUTINE PA(E)
      IMPLICIT REAL*8 (A-H,O-Z)
      COMMON T,T1,T2,E1(4),J,K,L
      DIMENSION E(4)

      J=0
 1    E(1)=(E(1)+E(2)+E(3)-E(4))*T
      E(2)=(E(1)+E(2)-E(3)+E(4))*T
      E(3)=(E(1)-E(2)+E(3)+E(4))*T
```

```
      E(4)=(-E(1)+E(2)+E(3)+E(4))/T2
      J=J+1
      IF(J-6)1,2,2
 2    CONTINUE
      RETURN
      END

      SUBROUTINE P0
      IMPLICIT REAL*8 (A-H,O-Z)
      COMMON T,T1,T2,E1(4),J,K,L
      E1(J)=E1(K)
      E1(K)=E1(L)
      E1(L)=E1(J)
      RETURN
      END

      SUBROUTINE P3(X,Y,Z)
      IMPLICIT REAL*8 (A-H,O-Z)
      COMMON T,T1,T2,E1(4),J,K,L
      X1=X
      Y1=Y
      X1=T*(X1+Y1)
      Y1=T*(X1+Y1)
      Z=(X1+Y1)/T2
      RETURN
      END


      SUBROUTINE POUT(N,J,K,X1,X2,X3,X4)
      IMPLICIT REAL*8 (A-H,O-Z)
      WRITE(*,1)N,J,K,X1,X2,X3,X4
1     FORMAT(1X,3I7,4(1PE12.4))
      RETURN
      END


      SUBROUTINE TIMER(TIME)
C
C     THIS SUBROUTINE CALLS THE SYSTEM TIME FOR THE DSI-780 BOARD
C     BOTH NDP AND IBM RT FORTRANS REQUIRE DIFFERENT UNIQUE CALLS
C
      EXTERNAL GTIME
      CALL GTIME(ITIME)
      IHOUR =ISHFT(ITIME,-24)
      IMIN  =ISHFT(IAND(16711680,ITIME),-16)
      ISEC  =ISHFT(IAND(65280,ITIME),-8)
      IMSEC =IAND(255,ITIME)
      TIME =(IHOUR*60.*60.+IMIN*60.+ISEC*1.+IMSEC/100.)
      RETURN
      END
```

APPENDIX D. BENCH BENCHMARK PROGRAM

```
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C
C       BENCH.FOR
C       WRITTEN BY  PROF. J. BREAKALL
C                   NAVAL POSTGRADUATE SCHOOL
C                   MONTEREY CA
C       BENCH IS A BENCHMARK PROGRAM DESIGNED TO TEST A COMPUTERS
C       ABILITY TO DO VARIOUS COMPUTATIONS. THE TIME IT TAKES TO
C       DO THESE VARIOUS ROUTINES IS SENT TO THE SCREEN IN SECONDS
C                   AREAS TESTED INCLUDE:
C                       DO LOOPS
C                       INTEGER ADDS
C                       INTEGER MULTIPLIES
C                       REAL ADDS
C                       REAL MULTIPLIES
C
C       NUMBER OF ITERATIONS USED TO CALCULATE THE TIMES IS CHOSEN
C       BY THE USER.
C
C       NOTE: ALL OPTIMIZATIONS MUST BE TURNED OFF FOR COMPILING
C
C       SECOND AND GETTIM ARE SUBROUTINES USED BY NDP FORTRAN FOR
C       CALLING THE SYSTEM TIME.
C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C
C***  QUERY USER FOR # OF ITERATIONS FOR EACH OPERATION
C     TEST FOR TERMINATION (-999)
C
10    WRITE (*,*) ' ENTER NO. TIMES (-999 STOP) > '
      READ (*,*) NTIM
      IF (NTIM .EQ. -999) STOP
C
C***  SET TIMER START DO LOOPS
C
      ITIM=0
      CALL SECOND(ITIM)
      TIM1=DBLE(ITIM)/100.
        DO 20 I=1,NTIM
20      CONTINUE
C
C***  END TIMER FOR DO LOOPS
C
      ITIM=0
      CALL SECOND(ITIM)
      TIM2=DBLE(ITIM)/100.
      DT1=TIM2-TIM1
      WRITE (*,*) ' DO LOOP ', DT1
      II=1234
```

```
      J=5678
C
C***  START TIMER FOR INTEGER ADDS
C
      ITIM=0
      CALL SECOND(ITIM)
      TIM3=DBLE(ITIM)/100.
        DO 30 I=1,NTIM
        K=II+J
30      CONTINUE
C
C***  END TIMER FOR INTEGER ADDS
C
      ITIM=0
      CALL SECOND(ITIM)
      TIM4=DBLE(ITIM)/100.
      DT2=TIM4-TIM3-DT1
      WRITE (*,*) ' INTEGER ADD ', DT2
C
C***  START TIMER FOR INTEGER MULTIPLIES
C
      ITIM=0
      CALL SECOND(ITIM)
      TIM5=DBLE(ITIM)/100.
         DO 40 I=1,NTIM
         K=II*J
40       CONTINUE
C
C***  END TIMER FOR INTEGER MULTIPLIES
C
      ITIM=0
      CALL SECOND(ITIM)
      TIM6=DBLE(ITIM)/100.
      DT3=TIM6-TIM5-DT1
      WRITE (*,*) ' INTEGER MULTIPLY ', DT3
      A=1234.
      B=5678.
C
C***  START TIMER FOR REAL ADDS
C
      ITIM=0
      CALL SECOND(ITIM)
      TIM7=DBLE(ITIM)/100.
        DO 50 I=1,NTIM
        C=A+B
50      CONTINUE
C
C***  END TIMER FOR REAL ADDS
C
      ITIM=0
      CALL SECOND(ITIM)
      TIM8=DBLE(ITIM)/100.
      DT4=TIM8-TIM7-DT1
      WRITE (*,*) ' REAL ADD ', DT4
C
```

```
C***  START TIMER FOR REAL MULTIPLIES
C
      ITIM=0
      CALL SECOND(ITIM)
      TIM9=DBLE(ITIM)/100.
        DO 60 I=1,NTIM
        C=A*B
60      CONTINUE
C
C***  END TIMER FOR REAL MULTIPLIES
C
      ITIM=0
      CALL SECOND(ITIM)
      TIM10=DBLE(ITIM)/100.
      DT5=TIM10-TIM9-DT1
      WRITE (*,*) ' REAL MULTIPLY ', DT5
      GO TO 10
      STOP
      END
```

APPENDIX E. MANSIZE: BENCHMARK TO FIND MANTISSA SIZE

```
****************************************************************
*                                                              *
*       MANSIZE                                                *
*                                                              *
*       MANSIZE IS A COMBINATION OF PROGRAMS THAT              *
*       DETERMINE THE NUMBER OF BITS OF ACCURACY USED          *
*       BY THE PC (LENGTH OF MANTISSA) WRITTEN BY              *
*       PROF. J. BREAKALL, NAVAL POSTGRADUATE SCHOOL,          *
*       MONTEREY CA. , AND A PROGRAM THAT DETERMINES           *
*       THE SMALLEST REPRESENTABLE NUMBER FOR A GIVEN          *
*       COMPUTER, WRITTEN BY, TIMOTHY M. O'HARA, NAVAL         *
*       POSTGRADUATE SCHOOL, MONTEREY CA.                      *
*                                                              *
****************************************************************
C
        A = 1.
        B = 1.
10      B = B/2
        C = A+B
           IF(A.EQ.C) THEN
C
C          MULTIPLY MANTISSA (B) BY 2 TO GET LAST RECOGNIZABLE VALUE
C
           B=2*B
C
C          CALCULATE THE NUMBER OF BITS IN MANTISSA
C
           BITS = -NINT(LOG10(B)/LOG10(2.))
C
           WRITE(*,*) 'NUMBER OF BITS IN MANTISSA = ',BITS
           WRITE(*,*) 'SMALLEST RECOGNIZABLE MANTISSA = ',B
           GO TO 100
           END IF
        GO TO 10
*
***     CALCULATE THE SMALLEST REPRESENTABLE NUMBER FOR EACH MACHINE
*
100     SMALL = 1.
        WRITE(*,*)
110     WRITE(*,200)SMALL
        SMALL = SMALL/2.
          IF(SMALL.NE.0) THEN
          GO TO 110
          END IF
200     FORMAT('+','SMALLEST REPRESENTABLE NUMBER = ',E12.6)
        STOP
        END
```

APPENDIX F. CMATVRT: MATRIX INVERTING PROGRAM

```
C
C       CMATVRT - A BENCHMARK FOR TESTING THE SPEED IN WHICH A
C       COMPLEX MATRIX CAN BE INVERTED AND STORED.
C
C       WRITTEN BY  PROF. M. MORGAN
C                   NAVAL POSTGRADUATE SCHOOL
C                   MONTEREY CA, 2 MARCH. 1987
C
C       MATFAC.FOR TO TEST FACTOR.FOR 3/2/87
        COMPLEX A(170,170),B(170,170),D(170),E(170)
        REAL RI,RR
        INTEGER P(170)
        CHARACTER BELL
        CALL TIMER(TIME0)
        BELL=CHAR(7)
        NMX=170
C       LOADING COMPLEX ARRAY A
        WRITE(*,*) 'ENTER MATRIX SIZE: N     '
        READ(*,*) N
        DO 25 I=1,N
        DO 22 K=1,N
        IK=IABS(I-K)
        EK=EXP(-.01*IK)
        RR=EK*COS(1.0*IK)
        RI=EK*SIN(1.0*IK)
        A(I,K)=CMPLX(RR,RI)
22      B(I,K)=(0.,0.)
25      B(I,I)=(1.,0.)
C       WRITE(*,*) BELL
C       PAUSE 'BEGIN MATRIX INVERSION'
C
CCCC    START FACTOR TIMER
C
        CALL TIMER(TIME1)
C
        CALL FACTOR(A,P,D,N,NMX)
C
CCCC    START INVERT TIMER
C
        CALL TIMER(TIME2)
C
        CALL INVERT(A,B,P,D,N,NMX,N,NMX)
C
CCCC    START INVERT TIMER
C
        CALL TIMER(TIME3)
C
C       WRITE(*,*) BELL
C       PAUSE 'MATRIX INVERTED'
        DO 35 I=1,N
        DO 35 K=1,N
```

```
      IK=IABS(I-K)
      EK=EXP(-.01*IK)
      RR=EK*COS(1.0*IK)
      RI=EK*SIN(1.0*IK)
35    A(I,K)=CMPLX(RR,RI)
      DO 55 I=1,N
      DO 44 K=1,N
      D(K)=(0.,0.)
      DO 33 L=1,N
      D(K)=D(K)+A(I,L)*B(L,K)
33    CONTINUE
44    CONTINUE
      I1=1
      IN=N
C     WRITE(*,100) I,I1,D(I1)
C     WRITE(*,100) I,I,D(I)
C     WRITE(*,100) I,IN,D(IN)
55    CONTINUE
C
C     STOP TIMER AND COMPUTE TOTAL TIME TO EXECUTE PROGRAM
C
      TIME = TIME2 - TIME1
      WRITE(*,*) '      MATRIX FILL TIME = ',TIME,' SECS'
      TIME = TIME3 - TIME2
      WRITE(*,*) ' MATRIX INVERSION TIME = ',TIME,' SECS'
      CALL TIMER(TIME4)
      TIME = TIME4 - TIME0
      WRITE(*,*) '      PROGRAM RUN TIME = ',TIME,' SECS'
100   FORMAT(' ',2I5,3X,2(1PE12.3))
      STOP
      END
C
      SUBROUTINE FACTOR (A,P,D,N,NMX)
C
      DIMENSION A(NMX,NMX),D(NMX),P(NMX)
      COMPLEX A,D,DETER
      INTEGER R,P,RM1,RP1,PJ,PR
      DO 60 R=1,N
      DO 10 K=1,N
      D(K)=A(K,R)
   10 CONTINUE
      RM1=R-1
      IF(RM1.LT.1) GO TO 31
      DO 30 J=1,RM1
      PJ=P(J)
      A(J,R)=D(PJ)
      D(PJ)=D(J)
      JP1=J+1
      DO 20 I=JP1,N
      D(I)=D(I)-A(I,J)*A(J,R)
   20 CONTINUE
   30 CONTINUE
   31 CONTINUE
      DMAX=CABS(D(R))
      P(R)=R
      RP1=R+1
```

```
      IF(RP1.GT.N) GO TO 41
      DO 40 I=RP1,N
      ELMAG=CABS(D(I))
      IF(ELMAG.LT.DMAX) GO TO 40
      DMAX=ELMAG
      P(R)=I
   40 CONTINUE
   41 CONTINUE
C     IF(DMAX.LT.1.0E-15) PRINT 105,DMAX,R
      PR=P(R)
      A(R,R)=D(PR)
      D(PR)=D(R)
      IF(RP1.GT.N) GO TO 51
      DO 50 I=RP1,N
      A(I,R)=D(I)/A(R,R)
   50 CONTINUE
   51 CONTINUE
   60 CONTINUE
      FNORM=0.0
      DETER=(1.,0.)
      DO 70 R=1,N
      DETER=DETER*A(R,R)
      DMAG=CABS(DETER)
      IF(DMAG.LT.1.0E10) GO TO 1
      DETER=DETER*1.0E-10
      FNORM=FNORM+10.
    1 CONTINUE
      IF(DMAG.GT.1.0E-10) GO TO 2
      DETER=DETER*1.0E10
      FNORM=FNORM-10.
    2 CONTINUE
C     IF(ABS(FNORM).GT.9.0) PRINT 104,DMAG,FNORM,R
   70 CONTINUE
  104 FORMAT (1H0,'CABS(DETER)= ',1PE12.3,' X 10 TO THE POWER ',
     1 0PF5.0,'  AT COLUMN  ',I3)
  105 FORMAT (1H0,'MAXIMUM PIVOT = ',E13.2,' AT COLUMN ',I3)
      RETURN
      END
C
      SUBROUTINE INVERT (A,B,P,Y,N,NMX,M,MMX)
C
      DIMENSION A(NMX,NMX),B(NMX,MMX),P(NMX),Y(NMX)
      COMPLEX A,B,Y,SUM
      INTEGER P,PI
      DO 50 L=1,M
      DO 20 I=1,N
      PI=P(I)
      Y(I)=B(PI,L)
      B(PI,L)=B(I,L)
      IP1=I+1
      IF(IP1.GT.N) GO TO 11
      DO 10 J=IP1,N
      B(J,L)=B(J,L)-A(J,I)*Y(I)
   10 CONTINUE
   11 CONTINUE
   20 CONTINUE
```

```
      DO 40 K=1,N
      I=N-K+1
      SUM=(0.,0.)
      IP1=I+1
      IF(IP1.GT.N) GO TO 31
      DO 30 J=IP1,N
      SUM=SUM+A(I,J)*B(J,L)
   30 CONTINUE
   31 CONTINUE
      B(I,L)=(Y(I)-SUM)/A(I,I)
   40 CONTINUE
   50 CONTINUE
      RETURN
      END
C
C***  TIMER IS A DSI-780 SPECIFIC SUBROUTINE TO CALL THE
C***  SYSTEM TIME AND CONVERT IT TO SECS.
C
      SUBROUTINE TIMER(TIME)
      CALL GTIME(ITIME)
      IHOUR =ISHFT(ITIME,-24)
      IMIN  =ISHFT(IAND(16711680,ITIME),-16)
      ISEC  =ISHFT(IAND(65280,ITIME),-8)
      IMSEC =IAND(255,ITIME)
      TIME =(IHOUR*60.*60.+IMIN*60.+ISEC*1.+IMSEC/100.)
      RETURN
      END
```

APPENDIX G. NEC3 SAMPLE RUNS ON IBM RT PC

A. RTG2.OUT (MONOPOLE WITH LOSSY GROUND, REQUIRES SOMNTX DATA)

```
                    ****************************************

                      NUMERICAL ELECTROMAGNETICS CODE (NPG1000)

                    ****************************************


                        - - - - COMMENTS - - - -

             *********************************************************


                  TEST PROBLEMS FOR THE NEW NEC-3 (NECG ALIAS NPGNEC)


             *********************************************************


                  #2 MONOPOLE ANTENNA ON A GROUND STAKE


                     - - - STRUCTURE SPECIFICATION - - -

                         COORDINATES MUST BE INPUT IN
                         METERS OR BE SCALED TO METERS
                         BEFORE STRUCTURE INPUT IS ENDED
```

WIRE NO.	X1	Y1	Z1	X2	Y2	Z2	RADIUS	NO. OF SEG.	FIRST SEG.	LAST SEG.	TAG NO.
1	.00000	.00000	-2.00000	.00000	.00000	.00000	.01000	8	1	8	1
2	.00000	.00000	.00000	.00000	.00000	15.00000	.01000	10	9	18	2

```
  TOTAL SEGMENTS USED=   18     NO. SEG. IN A SYMMETRIC CELL=   18     SYMMETRY FLAG=  0


        - MULTIPLE WIRE JUNCTIONS -
 JUNCTION    SEGMENTS  (- FOR END 1, + FOR END 2)
  NONE


                      - - - - - - FREQUENCY - - - - - -

                         FREQUENCY=  .5000E+01 MHZ
                         WAVELENGTH=  .5996E+02 METERS
```

THIS STRUCTURE IS NOT LOADED

- - - ANTENNA ENVIRONMENT - - -

FINITE GROUND. SOMMERFELD SOLUTION
RELATIVE DIELECTRIC CONST.= 10.000
CONDUCTIVITY= .100E-01 MHOS/METER
COMPLEX DIELECTRIC CONSTANT= .10000E+02 -.35951E+02

APPROXIMATE INTEGRATION EMPLOYED FOR SEGMENTS MORE THAN 59.960 METERS APART

- - - MATRIX TIMING - - -

FILL= 82 SEC., FACTOR= 1 SEC.

- - - ANTENNA INPUT PARAMETERS - - -

TAG NO.	SEG. NO.	VOLTAGE (VOLTS) REAL	IMAG.	CURRENT (AMPS) REAL	IMAG.	IMPEDANCE (OHMS) REAL	IMAG.	ADMITTANCE (MHOS) REAL	IMAG.	POWER (WATTS)
2	9	.10000E+01	.00000E+00	.14592E-01	.76103E-02	.53875E+02	-.28097E+02	.14592E-01	.76103E-02	.72962E-02

- - - POWER BUDGET - - -

INPUT POWER = .7296E-02 WATTS
RADIATED POWER= .7296E-02 WATTS
STRUCTURE LOSS= .0000E+00 WATTS
NETWORK LOSS = .0000E+00 WATTS
EFFICIENCY = 100.00 PERCENT

- - - RADIATION PATTERNS - - -

- - ANGLES - -		- POWER GAINS -			- - - POLARIZATION - - -			- - - E(THETA) - - -		- - - E(PHI) - - -	
THETA DEGREES	PHI DEGREES	VERT. DB	HOR. DB	TOTAL DB	AXIAL RATIO	TILT DEG.	SENSE	MAGNITUDE VOLTS/M	PHASE DEGREES	MAGNITUDE VOLTS/M	PHASE DEGREES
.00	.00	-999.99	-999.99	-999.99	.00000	.00		.00000E+00	.00	.00000E+00	.00
5.00	.00	-21.68	-999.99	-21.68	.00000	.00	LINEAR	.54530E-01	117.83	.00000E+00	.00
10.00	.00	-15.65	-999.99	-15.65	.00000	.00	LINEAR	.10912E+00	117.77	.00000E+00	.00
15.00	.00	-12.13	-999.99	-12.13	.00000	.00	LINEAR	.16377E+00	117.67	.00000E+00	.00
20.00	.00	-9.62	-999.99	-9.62	.00000	.00	LINEAR	.21840E+00	117.53	.00000E+00	.00
25.00	.00	-7.69	-999.99	-7.69	.00000	.00	LINEAR	.27278E+00	117.35	.00000E+00	.00
30.00	.00	-6.13	-999.99	-6.13	.00000	.00	LINEAR	.32653E+00	117.11	.00000E+00	.00
35.00	.00	-4.84	-999.99	-4.84	.00000	.00	LINEAR	.37900E+00	116.81	.00000E+00	.00
40.00	.00	-3.75	-999.99	-3.75	.00000	.00	LINEAR	.42932E+00	116.44	.00000E+00	.00
45.00	.00	-2.85	-999.99	-2.85	.00000	.00	LINEAR	.47629E+00	115.99	.00000E+00	.00

50.00	.00	-2.12	-999.99	-2.12	.00000	.00	LINEAR	.51837E+00	115.42	.00000E+00	.00
55.00	.00	-1.55	-999.99	-1.55	.00000	.00	LINEAR	.55358E+00	114.70	.00000E+00	.00
60.00	.00	-1.15	-999.99	-1.15	.00000	.00	LINEAR	.57934E+00	113.78	.00000E+00	.00
65.00	.00	-.96	-999.99	-.96	.00000	.00	LINEAR	.59216E+00	112.57	.00000E+00	.00
70.00	.00	-1.04	-999.99	-1.04	.00000	.00	LINEAR	.58696E+00	110.91	.00000E+00	.00
75.00	.00	-1.52	-999.99	-1.52	.00000	.00	LINEAR	.55537E+00	108.52	.00000E+00	.00
80.00	.00	-2.76	-999.99	-2.76	.00000	.00	LINEAR	.48148E+00	104.83	.00000E+00	.00
85.00	.00	-6.06	-999.99	-6.06	.00000	.00	LINEAR	.32907E+00	98.53	.00000E+00	.00
90.00	.00	-999.99	-999.99	-999.99	.00000	.00		.00000E+00	.00	.00000E+00	.00
.00	90.00	-999.99	-999.99	-999.99	.00000	.00		.00000E+00	.00	.00000E+00	.00
5.00	90.00	-21.68	-999.99	-21.68	.00000	.00	LINEAR	.54530E-01	117.83	.00000E+00	.00
10.00	90.00	-15.65	-999.99	-15.65	.00000	.00	LINEAR	.10912E+00	117.77	.00000E+00	.00
15.00	90.00	-12.13	-999.99	-12.13	.00000	.00	LINEAR	.16377E+00	117.67	.00000E+00	.00
20.00	90.00	-9.62	-999.99	-9.62	.00000	.00	LINEAR	.21840E+00	117.53	.00000E+00	.00
25.00	90.00	-7.69	-999.99	-7.69	.00000	.00	LINEAR	.27278E+00	117.35	.00000E+00	.00
30.00	90.00	-6.13	-999.99	-6.13	.00000	.00	LINEAR	.32653E+00	117.11	.00000E+00	.00
35.00	90.00	-4.84	-999.99	-4.84	.00000	.00	LINEAR	.37900E+00	116.81	.00000E+00	.00
40.00	90.00	-3.75	-999.99	-3.75	.00000	.00	LINEAR	.42932E+00	116.44	.00000E+00	.00
45.00	90.00	-2.85	-999.99	-2.85	.00000	.00	LINEAR	.47629E+00	115.99	.00000E+00	.00
50.00	90.00	-2.12	-999.99	-2.12	.00000	.00	LINEAR	.51837E+00	115.42	.00000E+00	.00
55.00	90.00	-1.55	-999.99	-1.55	.00000	.00	LINEAR	.55358E+00	114.70	.00000E+00	.00
60.00	90.00	-1.15	-999.99	-1.15	.00000	.00	LINEAR	.57934E+00	113.78	.00000E+00	.00
65.00	90.00	-.96	-999.99	-.96	.00000	.00	LINEAR	.59216E+00	112.57	.00000E+00	.00
70.00	90.00	-1.04	-999.99	-1.04	.00000	.00	LINEAR	.58696E+00	110.91	.00000E+00	.00
75.00	90.00	-1.52	-999.99	-1.52	.00000	.00	LINEAR	.55537E+00	108.52	.00000E+00	.00
80.00	90.00	-2.76	-999.99	-2.76	.00000	.00	LINEAR	.48148E+00	104.83	.00000E+00	.00
85.00	90.00	-6.06	-999.99	-6.06	.00000	.00	LINEAR	.32907E+00	98.53	.00000E+00	.00
90.00	90.00	-999.99	-999.99	-999.99	.00000	.00		.00000E+00	.00	.00000E+00	.00

AVERAGE POWER GAIN= .49751E+00 SOLID ANGLE USEDIN AVERAGING=(.5000)*PI STERADIANS.

***** DATA CARD NO. 6 NE 0 1 1 21 .50000E+04 .00000E+00 .00000E+00 .00000E+00 .00000E+00 .10000

- - - NEAR ELECTRIC FIELDS - - -

- LOCATION -			- EX -		- EY -		- EZ -		- PEAK FIELDS
X	Y	Z	MAGNITUDE	PHASE	MAGNITUDE	PHASE	MAGNITUDE	PHASE	MAGNITUDE
METERS	METERS	METERS	VOLTS/M	DEGREES	VOLTS/M	DEGREES	VOLTS/M	DEGREES	VOLTS/M
5000.0000	.0000	.0000	.2725E-05	43.55	.0000E+00	.00	.1671E-04	6.92	.1686E-04
5000.0000	.0000	10.0000	.2623E-05	44.55	.0000E+00	.00	.1519E-04	15.40	.1536E-04
5000.0000	.0000	20.0000	.2525E-05	45.21	.0000E+00	.00	.1407E-04	25.02	.1426E-04
5000.0000	.0000	30.0000	.2429E-05	45.52	.0000E+00	.00	.1339E-04	35.50	.1360E-04
5000.0000	.0000	40.0000	.2337E-05	45.44	.0000E+00	.00	.1319E-04	46.26	.1340E-04
5000.0000	.0000	50.0000	.2247E-05	44.97	.0000E+00	.00	.1345E-04	56.54	.1363E-04
5000.0000	.0000	60.0000	.2159E-05	44.09	.0000E+00	.00	.1412E-04	65.74	.1426E-04
5000.0000	.0000	70.0000	.2074E-05	42.77	.0000E+00	.00	.1510E-04	73.55	.1521E-04
5000.0000	.0000	80.0000	.1993E-05	40.98	.0000E+00	.00	.1632E-04	79.92	.1640E-04
5000.0000	.0000	90.0000	.1915E-05	38.71	.0000E+00	.00	.1771E-04	84.99	.1776E-04
5000.0000	.0000	100.0000	.1841E-05	35.92	.0000E+00	.00	.1922E-04	88.94	.1925E-04
5000.0000	.0000	110.0000	.1773E-05	32.60	.0000E+00	.00	.2079E-04	91.96	.2081E-04
5000.0000	.0000	120.0000	.1712E-05	28.72	.0000E+00	.00	.2241E-04	94.20	.2242E-04
5000.0000	.0000	130.0000	.1662E-05	24.41	.0000E+00	.00	.2407E-04	95.72	.2407E-04

5000.0000	.0000	140.0000	.1619E-05	19.52	.0000E+00	.00	.2572E-04	96.74	.2573E-0[illegible]
5000.0000	.0000	150.0000	.1584E-05	13.99	.0000E+00	.00	.2737E-04	97.35	.2737E-04
5000.0000	.0000	160.0000	.1562E-05	7.98	.0000E+00	.00	.2901E-04	97.55	.2901E-04
5000.0000	.0000	170.0000	.1555E-05	1.57	.0000E+00	.00	.3063E-04	97.40	.3063E-04
5000.0000	.0000	180.0000	.1562E-05	-5.12	.0000E+00	.00	.3223E-04	96.93	.3223E-04
5000.0000	.0000	190.0000	.1586E-05	-12.00	.0000E+00	.00	.3382E-04	96.18	.3382E-04
5000.0000	.0000	200.0000	.1626E-05	-18.92	.0000E+00	.00	.3538E-04	95.17	.3538E-04

```
***** DATA CARD NO.  7   EN   0    0    0    0   .00000E+00  .00000E+00  .00000E+00  .00000E+00  .00000E+00  .000001

RUN TIME =        121 SECS

INPUT DATA FILE

CM*****************************************************************
CM
CM      TEST PROBLEMS FOR THE NEW NEC-3 (NECG ALIAS NPGNEC)
CM
CM*****************************************************************
CM
CM      #2 MONOPOLE ANTENNA ON A GROUND STAKE
CM
CE
GW 1,8,0,0,-2.0,0,0,.01
GW 2,10,0,0,0,0,0,15,.01
GP
GE
FR 0,1,0,0,5
GN 2,0,0,0,10,.01
EX 0,2,1
PT -1
RP 0,19,2,1001,0,0,5,90
NE 0,1,1,21,5000,0,0,0,0,10
EN
```

B. RTROM.OUT (RHOMBIC ANTENNA)

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                    ********************************************

                      NUMERICAL ELECTROMAGNETICS CODE (NPG1000)

                    ********************************************

                          - - - - COMMENTS - - - -

                 TEST OF NPSNEC AS ON C DISK 7 FEB 83

                RHOMBIC ANTENNA HORIZONTALLY POLARIZED

                LEG LENGTH=398.0 FT.

                CENTER WIDTH=314.0 FT.

                APEX ANGLE=44.0 DEGREES.

                HEIGHT ABOVE GROUND=160.0 FT.

                GROUND PARAMETERS-EPSILON=80. SIGMA=4. MHOS/M. (SEA WATER)

                CONDUCTOR-AWG NO. 10 WIRE DIA.=0.00425 FT.

                   - - - STRUCTURE SPECIFICATION - - -

                      COORDINATES MUST BE INPUT IN
                      METERS OR BE SCALED TO METERS
                      BEFORE STRUCTURE INPUT IS ENDED

WIRE                                                                         NO. OF    FIRST  LAST    TAG
NO.        X1          Y1          Z1          X2          Y2          Z2        RADIUS   SEG.     SEG.   SEG.    NO.
   1     .00000      .00000   160.00000   366.08200   157.00000   160.00000     .00425     40         1    40      1
   2  366.08200   157.00000   160.00000   732.16400      .00000   160.00000     .00425     40        41    80      2
    STRUCTURE REFLECTED ALONG THE AXES   Y  .  TAGS INCREMENTED BY    2
    STRUCTURE SCALED BY FACTOR    .30480

 GROUND PLANE SPECIFIED.

 WHERE WIRE ENDS TOUCH GROUND, CURRENT WILL BE INTERPOLATED TO IMAGE IN GROUND PLANE.


 TOTAL SEGMENTS USED=  160     NO. SEG. IN A SYMMETRIC CELL=   80     SYMMETRY FLAG=  1
STRUCTURE HAS 1 PLANES OF SYMMETRY

       - MULTIPLE WIRE JUNCTIONS -
JUNCTION    SEGMENTS  (- FOR END 1, + FOR END 2)
 NONE
```

- - - - - - FREQUENCY - - - - - -

FREQUENCY= .1000E+02 MHZ
WAVELENGTH= .2998E+02 METERS

- - - STRUCTURE IMPEDANCE LOADING - - -

LOCATION			RESISTANCE	INDUCTANCE	CAPACITANCE	IMPEDANCE (OHMS)		CONDUCTIVITY	TYPE
ITAG	FROM	THRU	OHMS	HENRYS	FARADS	REAL	IMAGINARY	MHOS/METER	
2	40	40	.3000E+03						SER
4	40	40	.3000E+03						SER

- - - ANTENNA ENVIRONMENT - - -

FINITE GROUND. REFLECTION COEFFICIENT APPROXIMATION
RELATIVE DIELECTRIC CONST.= 80.000
CONDUCTIVITY= .400E+01 MHOS/METER
COMPLEX DIELECTRIC CONSTANT= .80000E+02 -.71902E+04

APPROXIMATE INTEGRATION EMPLOYED FOR SEGMENTS MORE THAN 29.980 METERS APART

- - - MATRIX TIMING - - -

FILL= 260 SEC., FACTOR= 51 SEC.

MAXIMUM RELATIVE ASYMMETRY OF THE DRIVING POINT ADMITTANCE MATRIX IS .165E-06 FOR SEGMENTS 81 AND 1
RMS RELATIVE ASYMMETRY IS .165E-06

- - - ANTENNA INPUT PARAMETERS - - -

TAG	SEG.	VOLTAGE (VOLTS)		CURRENT (AMPS)		IMPEDANCE (OHMS)		ADMITTANCE (MHOS)		POWER
NO.	NO.	REAL	IMAG.	REAL	IMAG.	REAL	IMAG.	REAL	IMAG.	(WATTS)
1	1	.50000E+00	.00000E+00	.11464E-02	-.56029E-03	.35205E+03	.17206E+03	.22928E-02	-.11206E-02	.28660E-03
3	81	-.50000E+00	.00000E+00	-.11464E-02	.56029E-03	.35205E+03	.17206E+03	.22928E-02	-.11206E-02	.28660E-03

- - - POWER BUDGET - - -

INPUT POWER = .5732E-03 WATTS

RADIATED POWER= .2881E-03 WATTS
STRUCTURE LOSS= .2851E-03 WATTS
NETWORK LOSS = .0000E+00 WATTS
EFFICIENCY = 50.27 PERCENT

- - - RADIATION PATTERNS - - -

- - ANGLES - -		- POWER GAINS -			- - - POLARIZATION - - -			- - - E(THETA) - - -		- - - E(PHI) - - -,	
THETA DEGREES	PHI DEGREES	VERT. DB	HOR. DB	TOTAL DB	AXIAL RATIO	TILT DEG.	SENSE	MAGNITUDE VOLTS/M	PHASE DEGREES	MAGNITUDE VOLTS/M	PHASE DEGREES
90.00	.00	-999.99	-999.99	-999.99	.00000	.00		.00000E+00	.00	.00000E+00	.00
85.00	.00	-139.99	15.87	15.87	.00000	-90.00	LINEAR	.18562E-07	-178.03	.11523E+01	-32.92
80.00	.00	-135.57	17.95	17.95	.00000	-90.00	LINEAR	.30887E-07	49.17	.14646E+01	-47.05
75.00	.00	-150.94	11.26	11.26	.00000	-90.00	LINEAR	.52600E-08	149.74	.67789E+00	-70.41
70.00	.00	-137.12	6.97	6.97	.00000	-90.00	LINEAR	.25829E-07	-45.78	.41361E+00	76.27
65.00	.00	-140.35	11.33	11.33	.00000	-90.00	LINEAR	.17807E-07	-76.45	.68304E+00	35.75
60.00	.00	-138.47	2.02	2.02	.00000	-90.00	LINEAR	.22104E-07	-106.34	.23405E+00	-11.28
55.00	.00	-136.72	-22.22	-22.22	.00000	-90.00	LINEAR	.27037E-07	48.14	.14353E-01	-114.88
50.00	.00	-148.74	-9.30	-9.30	.00000	-90.00	LINEAR	.67808E-08	146.31	.63580E-01	1.53
45.00	.00	-139.07	5.67	5.67	.00000	90.00	LINEAR	.20636E-07	-14.52	.35628E+00	-62.49
40.00	.00	-139.75	4.16	4.16	.00000	-90.00	LINEAR	.19084E-07	86.63	.29943E+00	-136.77
35.00	.00	-141.41	-15.80	-15.80	.00000	-90.00	LINEAR	.15761E-07	-8.75	.30059E-01	161.08
30.00	.00	-150.03	-8.90	-8.90	.00000	-90.00	LINEAR	.58401E-08	102.53	.66518E-01	4.93
25.00	.00	-143.88	-13.08	-13.08	.00000	-90.00	LINEAR	.11858E-07	26.57	.41127E-01	-79.92
20.00	.00	-135.23	-21.47	-21.47	.00000	90.00	LINEAR	.32092E-07	9.87	.15652E-01	9.80
15.00	.00	-153.06	-27.33	-27.33	.00000	-90.00	LINEAR	.41234E-08	46.74	.79747E-02	-157.08
10.00	.00	-144.04	-4.71	-4.71	.00000	-90.00	LINEAR	.11637E-07	-21.80	.10780E+00	123.69
5.00	.00	-140.26	-9.37	-9.37	.00000	90.00	LINEAR	.18000E-07	-54.06	.63009E-01	30.43
.00	.00	-147.81	-29.92	-29.92	.00000	90.00	LINEAR	.75395E-08	-165.96	.59149E-02	-179.21
-5.00	.00	-142.80	-6.52	-6.52	.00000	-90.00	LINEAR	.13436E-07	-12.53	.87510E-01	131.57
-10.00	.00	-140.69	-12.18	-12.18	.00000	-90.00	LINEAR	.17122E-07	-112.25	.45587E-01	43.21
-15.00	.00	-143.06	-36.54	-36.54	.00000	-90.00	LINEAR	.13028E-07	-49.40	.27614E-02	124.01
-20.00	.00	-151.63	-21.15	-21.15	.00000	-90.00	LINEAR	.48601E-08	8.13	.16240E-01	146.54
-25.00	.00	-140.10	-23.63	-23.63	.00000	90.00	LINEAR	.18335E-07	-77.47	.12202E-01	-99.44
-30.00	.00	-147.99	-22.32	-22.32	.00000	-90.00	LINEAR	.73872E-08	120.96	.14185E-01	-116.58
-35.00	.00	-144.59	-17.10	-17.10	.00000	-90.00	LINEAR	.10934E-07	170.54	.25896E-01	-.47
-40.00	.00	-151.36	-8.78	-8.78	.00000	90.00	LINEAR	.50116E-08	-116.57	.67487E-01	-46.48
-45.00	.00	-150.99	-10.77	-10.77	.00000	90.00	LINEAR	.52293E-08	-81.47	.53661E-01	-74.47
-50.00	.00	-145.58	-23.24	-23.24	.00000	90.00	LINEAR	.97523E-08	-164.62	.12762E-01	-114.31
-55.00	.00	-155.66	-44.48	-44.48	.00000	-90.00	LINEAR	.30543E-08	15.95	.11074E-02	-177.39
-60.00	.00	-149.39	-21.16	-21.16	.00000	90.00	LINEAR	.62921E-08	125.54	.16223E-01	-151.98
-65.00	.00	-154.03	-8.60	-8.60	.00000	90.00	LINEAR	.36868E-08	-56.98	.68910E-01	-132.69
-70.00	.00	-153.25	-10.35	-10.35	.00000	-90.00	LINEAR	.40338E-08	82.87	.56301E-01	-163.56
-75.00	.00	-156.14	-4.83	-4.83	.00000	90.00	LINEAR	.28897E-08	-58.39	.10632E+00	-12.54
-80.00	.00	-150.53	2.51	2.51	.00000	90.00	LINEAR	.55145E-08	-104.68	.24738E+00	-35.40
-85.00	.00	-162.37	.74	.74	.00000	-90.00	LINEAR	.14111E-08	71.57	.20186E+00	-49.46
-90.00	.00	-999.99	-999.99	-999.99	.00000	.00		.00000E+00	.00	.00000E+00	.00

- - - - NORMALIZED GAIN - - - -

HORIZONTAL GAIN
NORMALIZATION FACTOR = 17.95 DB

- - ANGLES - -		GAIN	- - ANGLES - -		GAIN	- - ANGLES - -		GAIN
THETA	PHI	DB	THETA	PHI	DB	THETA	PHI	DB
DEGREES	DEGREES		DEGREES	DEGREES		DEGREES	DEGREES	
90.00	.00	-1017.94	25.00	.00	-31.03	-35.00	.00	-35.05
85.00	.00	-2.08	20.00	.00	-39.42	-40.00	.00	-25.73
80.00	.00	.00	15.00	.00	-45.28	-45.00	.00	-28.72
75.00	.00	-6.69	10.00	.00	-22.66	-50.00	.00	-41.20
70.00	.00	-10.98	5.00	.00	-27.33	-55.00	.00	-62.43
65.00	.00	-6.63	.00	.00	-47.88	-60.00	.00	-39.11
60.00	.00	-15.93	-5.00	.00	-24.47	-65.00	.00	-26.55
55.00	.00	-40.18	-10.00	.00	-30.14	-70.00	.00	-28.30
50.00	.00	-27.25	-15.00	.00	-54.49	-75.00	.00	-22.78
45.00	.00	-12.28	-20.00	.00	-39.10	-80.00	.00	-15.45
40.00	.00	-13.79	-25.00	.00	-41.59	-85.00	.00	-17.21
35.00	.00	-33.76	-30.00	.00	-40.28	-90.00	.00	-1017.94
30.00	.00	-26.86						

***** DATA CARD NO. 10 EN 0 0 0 0 .00000E+00 .00000E+00 .00000E+00 .00000E+00 .00000E+00 .00000E+00

RUN TIME = 391 SECS

INPUT DATA FILE

```
CM   TEST OF NPSNEC AS ON C DISK 7 FEB 83
CM RHOMBIC ANTENNA HORIZONTALLY POLARIZED
CM LEG LENGTH=398.0 FT.
CM CENTER WIDTH=314.0 FT.
CM APEX ANGLE=44.0 DEGREES.
CM HEIGHT ABOVE GROUND=160.0 FT.
CM GROUND PARAMETERS-EPSILON=80. SIGMA=4. MHOS/M. (SEA WATER)
CE CONDUCTOR-AWG NO. 10 WIRE DIA.=0.00425 FT.
GW1,40,0.0,0.0,160.0,366.082,157.0,160.0,0.00425
GW2,40,366.082,157.0,160.0,732.164,0.0,160.0,0.00425
GX2,010
GS0,0,0.304801
GP
GE1
FR0,0,0,0,10.0
GN0,0,0,0,80.0,4.0
LD0,2,40,40,300.0
LD0,4,40,40,300.0
EX0,1,1,0,0.5
PT -1
EX0,3,1,10,-0.5
PT -1
RP0,37,1,1401,90.0,0.0,-5.0,0.0
EN
```

C. RTDP49.OUT (49 SEGMENT CENTER FED DIPOLE)

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                              ***********************************************

                                NUMERICAL ELECTROMAGNETICS CODE (NPGIOOO)

                              ***********************************************


                                    - - - - COMMENTS - - - -


                         DIPOLE WITH 49 SEGMENTS


                              - - - STRUCTURE SPECIFICATION - - -

                                   COORDINATES MUST BE INPUT IN
                                   METERS OR BE SCALED TO METERS
                                   BEFORE STRUCTURE INPUT IS ENDED


  WIRE                                                                         NO. OF    FIRST  LAST     TAG
  NO.        X1         Y1         Z1          X2         Y2         Z2      RADIUS   SEG.     SEG.   SEG.     NO.
    1     .00000     .00000     .00000      .00000     .00000     .50000     .00001     49        1     49       1

   TOTAL SEGMENTS USED=   49     NO. SEG. IN A SYMMETRIC CELL=   49     SYMMETRY FLAG=  0


         - MULTIPLE WIRE JUNCTIONS -
  JUNCTION    SEGMENTS  (- FOR END 1, + FOR END 2)
   NONE


                              - - - - - - FREQUENCY - - - - - -

                                 FREQUENCY=  .2998E+03 MHZ
                                 WAVELENGTH=  .1000E+01 METERS



                             - - - STRUCTURE IMPEDANCE LOADING - - -

                                THIS STRUCTURE IS NOT LOADED


                                 - - - ANTENNA ENVIRONMENT - - -

                                        FREE SPACE
```

```
APPROXIMATE INTEGRATION EMPLOYED FOR SEGMENTS MORE THAN   1.000 METERS APART


                    - - - MATRIX TIMING - - -

              FILL=        40 SEC.,  FACTOR=         6 SEC.


                                   - - - ANTENNA INPUT PARAMETERS - - -

 TAG   SEG.    VOLTAGE (VOLTS)         CURRENT (AMPS)         IMPEDANCE (OHMS)        ADMITTANCE (MHOS)      POWER
 NO.   NO.    REAL        IMAG.       REAL        IMAG.       REAL        IMAG.       REAL        IMAG.     (WATTS)
   1    25  .10000E+01  .00000E+00  .95625E-02 -.55803E-02  .78010E+02  .45523E+02  .95625E-02 -.55803E-02  .47812E-02


                                  - - - POWER BUDGET - - -

                                     INPUT POWER   =  .4781E-02 WATTS
                                     RADIATED POWER=  .4781E-02 WATTS
                                     STRUCTURE LOSS=  .0000E+00 WATTS
                                     NETWORK LOSS  =  .0000E+00 WATTS
                                     EFFICIENCY    = 100.00 PERCENT


***** DATA CARD NO.  4   EN   0     0     0     0   .00000E+00   .00000E+00   .00000E+00   .00000E+00   .00000E+00   .00000E+00

 RUN TIME =          50 SECS

 INPUT DATA FILE

CE    DIPOLE WITH 49 SEGMENTS
GW 1,49,0,0,0,0,0,.5,.00001
GP
GE
EX 0,1,25
PT -1
XQ
EN
```

APPENDIX II. NEC3 SAMPLE RUNS ON DEFINICON DSI-780 BOARD

A. G2DSI.OUT (MONOPOLE WITH LOSSY GROUND, REQUIRES SOMNTX DATA)

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                         ******************************************

                           NUMERICAL ELECTROMAGNETICS CODE (NPG1000)

                         ******************************************

                            - - - - COMMENTS - - - -

                 ************************************************************

                          TEST PROBLEMS FOR THE NEW NEC-3 (NECG ALIAS NPGNEC)

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                          #2 MONOPOLE ANTENNA ON A GROUND STAKE


                         - - - STRUCTURE SPECIFICATION - - -

                            COORDINATES MUST BE INPUT IN
                            METERS OR BE SCALED TO METERS
                            BEFORE STRUCTURE INPUT IS ENDED

 WIRE                                                                       NO. OF    FIRST  LAST     TAG
 NO.       X1         Y1         Z1          X2          Y2          Z2      RADIUS   SEG.     SEG.   SEG.     NO.
   1     .00000     .00000   -2.00000      .00000      .00000      .00000     .01000      8        1      8       1
   2     .00000     .00000     .00000      .00000      .00000    15.00000     .01000     10        9     18       2

  TOTAL SEGMENTS USED=   18     NO. SEG. IN A SYMMETRIC CELL=   18     SYMMETRY FLAG=  0

        - MULTIPLE WIRE JUNCTIONS -
 JUNCTION    SEGMENTS  (- FOR END 1, + FOR END 2)
  NONE


                         - - - - - - FREQUENCY - - - - - -

                           FREQUENCY=  .5000E+01 MHZ
                           WAVELENGTH=  .5996E+02 METERS


                        - - - STRUCTURE IMPEDANCE LOADING - - -

                          THIS STRUCTURE IS NOT LOADED

                           - - - ANTENNA ENVIRONMENT - - -

                              FINITE GROUND.  SOMMERFELD SOLUTION
                              RELATIVE DIELECTRIC CONST.= 10.000
                              CONDUCTIVITY=  .100E-01 MHOS/METER
                              COMPLEX DIELECTRIC CONSTANT=  .10000E+02 -.35951E+02
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APPROXIMATE INTEGRATION EMPLOYED FOR SEGMENTS MORE THAN 59.960 METERS APART

- - - MATRIX TIMING - - -

FILL= 56.301 SEC., FACTOR= .328 SEC.

- - - ANTENNA INPUT PARAMETERS - - -

TAG	SEG.	VOLTAGE (VOLTS)		CURRENT (AMPS)		IMPEDANCE (OHMS)		ADMITTANCE (MHOS)		POWER
NO.	NO.	REAL	IMAG.	REAL	IMAG.	REAL	IMAG.	REAL	IMAG.	(WATTS)
2	9	.10000E+01	.00000E+00	.89225E-02	-.35776E-02	.96553E+02	.38714E+02	.89225E-02	-.35776E-02	.44612E-02

- - - POWER BUDGET - - -

INPUT POWER = .4461E-02 WATTS
RADIATED POWER= .4461E-02 WATTS
STRUCTURE LOSS= .0000E+00 WATTS
NETWORK LOSS = .0000E+00 WATTS
EFFICIENCY = 100.00 PERCENT

- - - RADIATION PATTERNS - - -

- - ANGLES - -		- POWER GAINS -			- - - POLARIZATION - - -			- - - E(THETA) - - -		- - - E(PHI) - - -,	
THETA	PHI	VERT.	HOR.	TOTAL	AXIAL	TILT	SENSE	MAGNITUDE	PHASE	MAGNITUDE	PHASE
DEGREES	DEGREES	DB	DB	DB	RATIO	DEG.		VOLTS/M	DEGREES	VOLTS/M	DEGREES
.00	.00	-999.99	-999.99	-999.99	.00000	.00		.00000E+00	.00	.00000E+00	.00
5.00	.00	-23.66	-999.99	-23.66	.00000	.00	LINEAR	.33939E-01	66.38	.00000E+00	.00
10.00	.00	-17.63	-999.99	-17.63	.00000	.00	LINEAR	.67937E-01	66.30	.00000E+00	.00
15.00	.00	-14.10	-999.99	-14.10	.00000	.00	LINEAR	.10202E+00	66.17	.00000E+00	.00
20.00	.00	-11.59	-999.99	-11.59	.00000	.00	LINEAR	.13617E+00	65.99	.00000E+00	.00
25.00	.00	-9.65	-999.99	-9.65	.00000	.00	LINEAR	.17024E+00	65.75	.00000E+00	.00
30.00	.00	-8.08	-999.99	-8.08	.00000	.00	LINEAR	.20401E+00	65.46	.00000E+00	.00
35.00	.00	-6.78	-999.99	-6.78	.00000	.00	LINEAR	.23708E+00	65.10	.00000E+00	.00
40.00	.00	-5.68	-999.99	-5.68	.00000	.00	LINEAR	.26890E+00	64.67	.00000E+00	.00
45.00	.00	-4.77	-999.99	-4.77	.00000	.00	LINEAR	.29870E+00	64.15	.00000E+00	.00
50.00	.00	-4.02	-999.99	-4.02	.00000	.00	LINEAR	.32550E+00	63.52	.00000E+00	.00
55.00	.00	-3.44	-999.99	-3.44	.00000	.00	LINEAR	.34801E+00	62.75	.00000E+00	.00
60.00	.00	-3.04	-999.99	-3.04	.00000	.00	LINEAR	.36460E+00	61.78	.00000E+00	.00
65.00	.00	-2.84	-999.99	-2.84	.00000	.00	LINEAR	.37303E+00	60.52	.00000E+00	.00
70.00	.00	-2.91	-999.99	-2.91	.00000	.00	LINEAR	.37006E+00	58.81	.00000E+00	.00
75.00	.00	-3.38	-999.99	-3.38	.00000	.00	LINEAR	.35038E+00	56.39	.00000E+00	.00
80.00	.00	-4.62	-999.99	-4.62	.00000	.00	LINEAR	.30390E+00	52.68	.00000E+00	.00
85.00	.00	-7.92	-999.99	-7.92	.00000	.00	LINEAR	.20777E+00	46.36	.00000E+00	.00
90.00	.00	-999.99	-999.99	-999.99	.00000	.00		.00000E+00	.00	.00000E+00	.00
.00	90.00	-999.99	-999.99	-999.99	.00000	.00		.00000E+00	.00	.00000E+00	.00
5.00	90.00	-23.66	-999.99	-23.66	.00000	.00	LINEAR	.33939E-01	66.38	.00000E+00	.00
10.00	90.00	-17.63	-999.99	-17.63	.00000	.00	LINEAR	.67937E-01	66.30	.00000E+00	.00
15.00	90.00	-14.10	-999.99	-14.10	.00000	.00	LINEAR	.10202E+00	66.17	.00000E+00	.00
20.00	90.00	-11.59	-999.99	-11.59	.00000	.00	LINEAR	.13617E+00	65.99	.00000E+00	.00
25.00	90.00	-9.65	-999.99	-9.65	.00000	.00	LINEAR	.17024E+00	65.75	.00000E+00	.00
30.00	90.00	-8.08	-999.99	-8.08	.00000	.00	LINEAR	.20401E+00	65.46	.00000E+00	.00
35.00	90.00	-6.78	-999.99	-6.78	.00000	.00	LINEAR	.23708E+00	65.10	.00000E+00	.00

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  40.00    90.00     -5.68 -999.99   -5.68    .00000     .00 LINEAR    .26890E+00   64.67    .00000E+00     .00
  45.00    90.00     -4.77 -999.99   -4.77    .00000     .00 LINEAR    .29870E+00   64.15    .00000E+00     .00
  50.00    90.00     -4.02 -999.99   -4.02    .00000     .00 LINEAR    .32550E+00   63.52    .00000E+00     .00
  55.00    90.00     -3.44 -999.99   -3.44    .00000     .00 LINEAR    .34801E+00   62.75    .00000E+00     .00
  60.00    90.00     -3.04 -999.99   -3.04    .00000     .00 LINEAR    .36460E+00   61.78    .00000E+00     .00
  65.00    90.00     -2.84 -999.99   -2.84    .00000     .00 LINEAR    .37303E+00   60.52    .00000E+00     .00
  70.00    90.00     -2.91 -999.99   -2.91    .00000     .00 LINEAR    .37006E+00   58.81    .00000E+00     .00
  75.00    90.00     -3.38 -999.99   -3.38    .00000     .00 LINEAR    .35038E+00   56.39    .00000E+00     .00
  80.00    90.00     -4.62 -999.99   -4.62    .00000     .00 LINEAR    .30390E+00   52.68    .00000E+00     .00
  85.00    90.00     -7.92 -999.99   -7.92    .00000     .00 LINEAR    .20777E+00   46.36    .00000E+00     .00
  90.00    90.00   -999.99 -999.99 -999.99    .00000     .00           .00000E+00     .00    .00000E+00     .00

  AVERAGE POWER GAIN=  .32211E+00      SOLID ANGLE USEDIN AVERAGING=(,  .5000)*PI STERADIANS.


                              - - - NEAR ELECTRIC FIELDS - - -

           -  LOCATION  -                 -  EX  -              -  EY  -              -  EZ  -          - PEAK FIEL
DS -
       X           Y          Z        MAGNITUDE   PHASE     MAGNITUDE   PHASE     MAGNITUDE  PHASE        MAGNITUDE
     METERS      METERS     METERS      VOLTS/M   DEGREES     VOLTS/M   DEGREES     VOLTS/M  DEGREES        VOLTS/M
    5000.0000      .0000      .0000    .1720E-05    -8.63   .0000E+00     .00    .1055E-04  -45.25        .1064E-04
    5000.0000      .0000    10.0000    .1656E-05    -7.62   .0000E+00     .00    .9592E-05  -36.78        .9701E-05
    5000.0000      .0000    20.0000    .1594E-05    -6.96   .0000E+00     .00    .8881E-05  -27.16        .9006E-05
    5000.0000      .0000    30.0000    .1534E-05    -6.66   .0000E+00     .00    .8453E-05  -16.68        .8587E-05
    5000.0000      .0000    40.0000    .1475E-05    -6.73   .0000E+00     .00    .8329E-05   -5.92        .8459E-05
    5000.0000      .0000    50.0000    .1419E-05    -7.20   .0000E+00     .00    .8495E-05    4.36        .8608E-05
    5000.0000      .0000    60.0000    .1363E-05    -8.08   .0000E+00     .00    .8915E-05   13.57        .9005E-05
    5000.0000      .0000    70.0000    .1310E-05    -9.41   .0000E+00     .00    .9536E-05   21.37        .9603E-05
    5000.0000      .0000    80.0000    .1258E-05   -11.19   .0000E+00     .00    .1031E-04   27.75        .1035E-04
    5000.0000      .0000    90.0000    .1209E-05   -13.47   .0000E+00     .00    .1118E-04   32.82        .1122E-04
    5000.0000      .0000   100.0000    .1163E-05   -16.25   .0000E+00     .00    .1213E-04   36.77        .1215E-04
    5000.0000      .0000   110.0000    .1120E-05   -19.58   .0000E+00     .00    .1313E-04   39.78        .1314E-04
    5000.0000      .0000   120.0000    .1081E-05   -23.45   .0000E+00     .00    .1415E-04   42.03        .1415E-04
    5000.0000      .0000   130.0000    .1049E-05   -27.76   .0000E+00     .00    .1519E-04   43.55        .1520E-04
    5000.0000      .0000   140.0000    .1022E-05   -32.65   .0000E+00     .00    .1624E-04   44.57        .1624E-04
    5000.0000      .0000   150.0000    .1000E-05   -38.18   .0000E+00     .00    .1728E-04   45.17        .1728E-04
    5000.0000      .0000   160.0000    .9864E-06   -44.19   .0000E+00     .00    .1831E-04   45.37        .1831E-04
    5000.0000      .0000   170.0000    .9815E-06   -50.60   .0000E+00     .00    .1934E-04   45.23        .1934E-04
    5000.0000      .0000   180.0000    .9863E-06   -57.29   .0000E+00
 Programmed STOP
   .00     .2035E-04    44.76        .2035E-04
    5000.0000      .0000   190.0000    .1001E-05   -64.17   .0000E+00     .00    .2135E-04   44.01        .2135E-04
    5000.0000      .0000   200.0000    .1026E-05   -71.09   .0000E+00     .00    .2234E-04   43.00        .2234E-04

 ***** DATA CARD NO.  7   EN   0     0     0     0   .00000E+00   .00000E+00   .00000E+00   .00000E+00   .00000E+00   .000
00E+00

 RUN TIME =          88.859
*
*** INPUT DATA SET
*
CM*****************************************************************
CM
```

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CM      TEST PROBLEMS FOR THE NEW NEC-3 (NECG ALIAS NPGNEC)
CM
CM****************************************************************
CM
CM      #2 MONOPOLE ANTENNA ON A GROUND STAKE
CM
CE
GW 1,8,0,0,-2,0,0,0,.01
GW 2,10,0,0,0,0,0,15,.01
GP
GE
FR 0,1,0,0,5
GN 2,0,0,0,10,.01
EX 0,2,1
PT -1
RP 0,19,2,1001,0,0,5,90
NE 0,1,1,21,5000,0,0,0,0,10
EN
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B. ROMBCDSI.OUT (RHOMBIC ANTENNA)

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                    ********************************************

                    NUMERICAL ELECTROMAGNETICS CODE (NPGI000)

                    ********************************************

                            - - - - COMMENTS - - - -

               RHOMBIC ANTENNA HORIZONTALLY POLARIZED
               LEG LENGTH=398.0 FT.
               CENTER WIDTH=314.0 FT.
               APEX ANGLE=44.0 DEGREES.
               HEIGHT ABOVE GROUND=160.0 FT.
               GROUND PARAMETERS-EPSILON=80. SIGMA=4. MHOS/M. (SEA WATER)
               CONDUCTOR-AWG NO. 10 WIRE DIA.=0.00425 FT.

                        - - - STRUCTURE SPECIFICATION - - -

                           COORDINATES MUST BE INPUT IN
                           METERS OR BE SCALED TO METERS
                           BEFORE STRUCTURE INPUT IS ENDED

WIRE                                                                    NO. OF    FIRST  LAST     TAG
NO.        X1         Y1         Z1         X2         Y2         Z2     RADIUS   SEG.     SEG.   SEG.     NO.
   1    .00000     .00000  160.00000  366.08200  157.00000  160.00000    .00425    40        1     40       1
   2 366.08200  157.00000  160.00000  732.16400     .00000  160.00000    .00425    40       41     80       2
    STRUCTURE REFLECTED ALONG THE AXES  Y  .  TAGS INCREMENTED BY    2
    STRUCTURE SCALED BY FACTOR    .30480

  GROUND PLANE SPECIFIED.

  WHERE WIRE ENDS TOUCH GROUND, CURRENT WILL BE INTERPOLATED TO IMAGE IN GROUND PLANE.

  TOTAL SEGMENTS USED=  160     NO. SEG. IN A SYMMETRIC CELL=   80     SYMMETRY FLAG=  1
 STRUCTURE HAS 1 PLANES OF SYMMETRY


       - MULTIPLE WIRE JUNCTIONS -
 JUNCTION    SEGMENTS  (- FOR END 1, + FOR END 2)
  NONE

                        - - - - - - FREQUENCY - - - - - -

                           FREQUENCY=  .1000E+02 MHZ
                           WAVELENGTH=  .2998E+02 METERS


                      - - - STRUCTURE IMPEDANCE LOADING - - -

      LOCATION          RESISTANCE  INDUCTANCE  CAPACITANCE      IMPEDANCE (OHMS)     CONDUCTIVITY    TYPE
   ITAG FROM THRU          OHMS       HENRYS       FARADS        REAL      IMAGINARY   MHOS/METER
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2	40	40	.3000E+03	SER
4	40	40	.3000E+03	SER

- - - ANTENNA ENVIRONMENT - - -

FINITE GROUND. REFLECTION COEFFICIENT APPROXIMATION
RELATIVE DIELECTRIC CONST.= 80.000
CONDUCTIVITY= .400E+01 MHOS/METER
COMPLEX DIELECTRIC CONSTANT= .80000E+02 -.71902E+04

APPROXIMATE INTEGRATION EMPLOYED FOR SEGMENTS MORE THAN 29.980 METERS APART

- - - MATRIX TIMING - - -

FILL= 244.914 SEC., FACTOR= 53.227 SEC.

MAXIMUM RELATIVE ASYMMETRY OF THE DRIVING POINT ADMITTANCE MATRIX IS .137E-06 FOR SEGMENTS 81 AND 1
RMS RELATIVE ASYMMETRY IS .137E-06

- - - ANTENNA INPUT PARAMETERS - - -

TAG	SEG.	VOLTAGE (VOLTS)		CURRENT (AMPS)		IMPEDANCE (OHMS)		ADMITTANCE (MHOS)		POWER
NO.	NO.	REAL	IMAG.	REAL	IMAG.	REAL	IMAG.	REAL	IMAG.	(WATTS)
1	1	.50000E+00	.00000E+00	.11464E-02	-.56029E-03	.35206E+03	.17206E+03	.22928E-02	-.11206E-02	.28660E-03
3	81	-.50000E+00	.00000E+00	-.11464E-02	.56029E-03	.35206E+03	.17206E+03	.22928E-02	-.11206E-02	.28660E-03

- - - POWER BUDGET - - -

INPUT POWER = .5732E-03 WATTS
RADIATED POWER= .2881E-03 WATTS
STRUCTURE LOSS= .2851E-03 WATTS
NETWORK LOSS = .0000E+00 WATTS
EFFICIENCY = 50.27 PERCENT

- - - RADIATION PATTERNS - - -

- - ANGLES - -		- POWER GAINS -			- - - POLARIZATION - - -			- - - E(THETA) - - -		- - - E(PHI) - - -,	
THETA	PHI	VERT.	HOR.	TOTAL	AXIAL	TILT	SENSE	MAGNITUDE	PHASE	MAGNITUDE	PHASE
DEGREES	DEGREES	DB	DB	DB	RATIO	DEG.		VOLTS/M	DEGREES	VOLTS/M	DEGREES
90.00	.00	-999.99	-999.99	-999.99	.00000	.00		.00000E+00	.00	.00000E+00	.00
85.00	.00	-138.96	15.87	15.87	.00000	90.00	LINEAR	.20896E-07	12.51	.11523E+01	-32.92
80.00	.00	-134.44	17.95	17.95	.00000	-90.00	LINEAR	.35148E-07	-168.32	.14646E+01	-47.05
75.00	.00	-141.37	11.26	11.26	.00000	-90.00	LINEAR	.15835E-07	152.21	.67788E+00	-70.41
70.00	.00	-143.34	6.97	6.97	.00000	-90.00	LINEAR	.12620E-07	-50.63	.41360E+00	76.27
65.00	.00	-130.55	11.33	11.33	.00000	-90.00	LINEAR	.55024E-07	-90.32	.68303E+00	35.75
60.00	.00	-130.27	2.02	2.02	.00000	90.00	LINEAR	.56830E-07	-82.33	.23405E+00	-11.28
55.00	.00	-139.72	-22.22	-22.22	.00000	-90.00	LINEAR	.19135E-07	44.56	.14354E-01	-114.88

50.00	.00	-134.51	-9.30	-9.30	.00000	-90.00	LINEAR	.34871E-07	-93.87	.63580E-01	1.53
45.00	.00	-143.48	5.67	5.67	.00000	90.00	LINEAR	.12416E-07	-144.32	.35628E+00	-62.49
40.00	.00	-140.02	4.16	4.16	.00000	-90.00	LINEAR	.18490E-07	.00	.29943E+00	-136.77
35.00	.00	-136.70	-15.80	-15.80	.00000	-90.00	LINEAR	.27095E-07	-54.90	.30058E-01	161.08
30.00	.00	-142.00	-8.90	-8.90	.00000	90.00	LINEAR	.14734E-07	-64.54	.66518E-01	4.93
25.00	.00	-145.28	-13.08	-13.08	.00000	-90.00	LINEAR	.10097E-07	113.20	.41127E-01	-79.92
20.00	.00	-143.51	-21.47	-21.47	.00000	-90.00	LINEAR	.12372E-07	-90.00	.15651E-01	9.80
15.00	.00	-144.98	-27.33	-27.33	.00000	-90.00	LINEAR	.10445E-07	-18.74	.79750E-02	-157.08
10.00	.00	-148.21	-4.71	-4.71	.00000	90.00	LINEAR	.72033E-08	90.00	.10780E+00	123.69
5.00	.00	-153.49	-9.37	-9.37	.00000	-90.00	LINEAR	.39239E-08	158.20	.63008E-01	30.43
.00	.00	-137.80	-29.92	-29.92	.00000	90.00	LINEAR	.23884E-07	115.39	.59148E-02	-179.21
-5.00	.00	-142.39	-6.52	-6.52	.00000	-90.00	LINEAR	.14073E-07	-21.25	.87510E-01	131.57
-10.00	.00	-138.85	-12.18	-12.18	.00000	-90.00	LINEAR	.21152E-07	137.07	.45587E-01	43.21
-15.00	.00	-152.79	-36.54	-36.54	.00000	-90.00	LINEAR	.42538E-08	-138.37	.27613E-02	124.02
-20.00	.00	-146.47	-21.15	-21.15	.00000	90.00	LINEAR	.88021E-08	-128.66	.16240E-01	146.54
-25.00	.00	-147.96	-23.63	-23.63	.00000	90.00	LINEAR	.74116E-08	-79.70	.12202E-01	-99.44
-30.00	.00	-145.67	-22.32	-22.32	.00000	90.00	LINEAR	.96484E-08	-156.80	.14185E-01	-116.58
-35.00	.00	-157.77	-17.10	-17.10	.00000	-90.00	LINEAR	.23966E-08	90.00	.25896E-01	-.47
-40.00	.00	-157.38	-8.78	-8.78	.00000	90.00	LINEAR	.25058E-08	26.57	.67488E-01	-46.48
-45.00	.00	-148.51	-10.77	-10.77	.00000	-90.00	LINEAR	.69583E-08	131.99	.53662E-01	-74.47
-50.00	.00	-151.27	-23.24	-23.24	.00000	90.00	LINEAR	.50638E-08	-158.20	.12762E-01	-114.31
-55.00	.00	-156.37	-44.47	-44.47	.00000	-90.00	LINEAR	.28143E-08	63.43	.11078E-02	-177.38
-60.00	.00	-159.05	-21.16	-21.16	.00000	-90.00	LINEAR	.20688E-08	45.00	.16224E-01	-151.99
-65.00	.00	-153.62	-8.60	-8.60	.00000	90.00	LINEAR	.38640E-08	-53.13	.68908E-01	-132.69
-70.00	.00	-146.31	-10.35	-10.35	.00000	-90.00	LINEAR	.89677E-08	22.99	.56300E-01	-163.56
-75.00	.00	-160.79	-4.83	-4.83	.00000	90.00	LINEAR	.16932E-08	-26.57	.10632E+00	-12.54
-80.00	.00	-150.40	2.51	2.51	.00000	-90.00	LINEAR	.56016E-08	57.03	.24738E+00	-35.40
-85.00	.00	-154.72	.74	.74	.00000	90.00	LINEAR	.34051E-08	-128.16	.20186E+00	-49.46
-90.00	.00	-999.99	-999.99	-999.99	.00000	.00		.00000E+00	.00	.00000E+00	.00

- - - - NORMALIZED GAIN - - - -

HORIZONTAL GAIN
NORMALIZATION FACTOR = 17.95 DB

- - ANGLES - -		GAIN	- - ANGLES - -		GAIN	- - ANGLES - -		GAIN
THETA	PHI	DB	THETA	PHI	DB	THETA	PHI	DB
DEGREES	DEGREES		DEGREES	DEGREES		DEGREES	DEGREES	
90.00	.00	-1017.94	25.00	.00	-31.03	-35.00	.00	-35.05
85.00	.00	-2.08	20.00	.00	-39.42	-40.00	.00	-26.73
80.00	.00	.00	15.00	.00	-45.28	-45.00	.00	-28.72
75.00	.00	-6.69	10.00	.00	-22.66	-50.00	.00	-41.20
70.00	.00	-10.98	5.00	.00	-27.33	-55.00	.00	-62.43
65.00	.00	-6.63	.00	.00	-47.88	-60.00	.00	-39.11
60.00	.00	-15.93	-5.00	.00	-24.47	-65.00	.00	-26.55
55.00	.00	-40.18	-10.00	.00	-30.14	-70.00	.00	-28.30
50.00	.00	-27.25	-15.00	.00	-54.49	-75.00	.00	-22.78
45.00	.00	-12.28	-20.00	.00	-39.10	-80.00	.00	-15.45
40.00	.00	-13.79	-25.00	.00	-41.59	-85.00	.00	-17.21
35.00	.00	-33.76	-30.00	.00	-40.28	-90.00	.00	-1017.94
30.00	.00	-26.86						

Programmed STOP
NO. 10 EN 0 0 0 0 .00000E+00 .00000E+00 .00000E+00 .00000E+00 .00000E+00 .00000E+00

```
 RUN TIME =   359.867
*
*** INPUT DATA SET ***
*
CM   TEST OF NPSNEC AS ON C DISK 7 FEB 83
CM RHOMBIC ANTENNA HORIZONTALLY POLARIZED
CM LEG LENGTH=398.0 FT.
CM CENTER WIDTH=314.0 FT.
CM APEX ANGLE=44.0 DEGREES.
CM HEIGHT ABOVE GROUND=160.0 FT.
CM GROUND PARAMETERS-EPSILON=80. SIGMA=4. MHOS/M. (SEA WATER)
CE CONDUCTOR-AWG NO. 10 WIRE DIA.=0.00425 FT.
GW1,40,0.0,0.0,160.0,366.082,157.0,160.0,0.00425
GW2,40,366.082,157.0,160.0,732.164,0.0,160.0,0.00425
GX2,010
GS0,0,0.304801
GP
GE1
FR0,0,0.0.10.0
GN0,0,0,0,80.0,4.0
LD0,2,40,40,300.0
LD0,4,40,40,300.0
EX0,1,1,0,0.5
PT -1
EX0,3,1,10,-0.5
PT -1
RP0,37,1,1401,90.0,0.0,-5.0,0.0
EN
```

C. DP49DSI.OUT (49 SEGMENT CENTER FED DIPOLE)

```
                          ********************************************

                           NUMERICAL ELECTROMAGNETICS CODE (NPGI000)

                          ********************************************


                               - - - - COMMENTS - - - -

                       DIPOLE WITH 49 SEGMENTS


                          - - - STRUCTURE SPECIFICATION - - -

                              COORDINATES MUST BE INPUT IN
                              METERS OR BE SCALED TO METERS
                              BEFORE STRUCTURE INPUT IS ENDED


WIRE                                                            NO. OF   FIRST  LAST    TAG
NO.      X1      Y1      Z1       X2      Y2      Z2     RADIUS  SEG.     SEG.   SEG.    NO.
  1    .00000  .00000  .00000   .00000  .00000  .50000   .00001   49        1     49      1

 TOTAL SEGMENTS USED=  49    NO. SEG. IN A SYMMETRIC CELL=  49    SYMMETRY FLAG=  0


      - MULTIPLE WIRE JUNCTIONS -
JUNCTION    SEGMENTS  (- FOR END 1, + FOR END 2)
 NONE


                          - - - - - - FREQUENCY - - - - - -

                              FREQUENCY=  .2998E+03 MHZ
                              WAVELENGTH=  .1000E+01 METERS


                         - - - STRUCTURE IMPEDANCE LOADING - - -

                             THIS STRUCTURE IS NOT LOADED


                           - - - ANTENNA ENVIRONMENT - - -

                                     FREE SPACE
```

```
          APPROXIMATE INTEGRATION EMPLOYED FOR SEGMENTS MORE THAN   1.000 METERS APART


                    - - - MATRIX TIMING - - -

              FILL=       36.910 SEC.,  FACTOR=        6.148 SEC.


                                 - - - ANTENNA INPUT PARAMETERS - - -

 TAG  SEG.   VOLTAGE (VOLTS)        CURRENT (AMPS)         IMPEDANCE (OHMS)       ADMITTANCE (MHOS)      POWER
 NO.  NO.    REAL        IMAG.      REAL        IMAG.      REAL        IMAG.      REAL        IMAG.     (WATTS)
  1    25 .10000E+01  .00000E+00  .96941E-02 -.55202E-02  .77897E+02  .44358E+02  .96941E-02 -.55202E-02  .48470E-02


                                - - - POWER BUDGET - - -

                                  INPUT POWER   =  .4847E-02 WATTS
                                  RADIATED POWER=  .4847E-02 WATTS
                                  STRUCTURE LOSS=  .0000E+00 WATTS

 Programmed STOP
                                NETWORK LOSS  =  .0000E+00 WATTS
                                  EFFICIENCY    = 100.00 PERCENT




 ***** DATA CARD NO.  4   EN   0    0    0    0  .00000E+00  .00000E+00  .00000E+00  .00000E+00  .00000E+00  .000
00E+00

 RUN TIME =        44.602

INPUT DATA SET

CE   DIPOLE WITH 49 SEGMENTS
GW 1,49,0,0,0,0,0,.5,.00001
GP
GE
EX 0,1,25
PT -1
XQ
EN
```

APPENDIX I. NEC3 SAMPLE RUNS ON COMPAQ 386/20 (80387)

A. 387G2.OUT (MONOPOLE WITH LOSSY GROUND, REQUIRES SOMNTX DATA)

```
                    ********************************************

                    NUMERICAL ELECTROMAGNETICS CODE (NPG1000)

                    ********************************************


                    - - - - COMMENTS - - - -


          ************************************************************

              TEST PROBLEMS FOR THE NEW NEC-3 (NECG ALIAS NPGNEC)

          ************************************************************

              #2 MONOPOLE ANTENNA ON A GROUND STAKE



                  - - - STRUCTURE SPECIFICATION - - -

                     COORDINATES MUST BE INPUT IN
                     METERS OR BE SCALED TO METERS
                     BEFORE STRUCTURE INPUT IS ENDED


WIRE                                                                  NO. OF    FIRST  LAST     TAG
NO.      X1        Y1        Z1         X2        Y2        Z2       RADIUS   SEG.     SEG.   SEG.     NO.
  1   0.00000   0.00000  -2.00000   0.00000   0.00000   0.00000   0.01000     8         1      8       1
  2   0.00000   0.00000   0.00000   0.00000   0.00000  15.00000   0.01000    10         9     18       2

  TOTAL SEGMENTS USED=   18     NO. SEG. IN A SYMMETRIC CELL=   18     SYMMETRY FLAG=  0


       - MULTIPLE WIRE JUNCTIONS -
JUNCTION    SEGMENTS  (- FOR END 1, + FOR END 2)
 NONE

                  - - - - - - FREQUENCY - - - - - -

                     FREQUENCY= 0.5000E+01 MHZ
                     WAVELENGTH= 0.5996E+02 METERS



                  - - - STRUCTURE IMPEDANCE LOADING - - -

                     THIS STRUCTURE IS NOT LOADED
```

- - - ANTENNA ENVIRONMENT - - -

FINITE GROUND. SOMMERFELD SOLUTION
RELATIVE DIELECTRIC CONST.= 10.000
CONDUCTIVITY= 0.100E-01 MHOS/METER
COMPLEX DIELECTRIC CONSTANT= 0.10000E+02-0.35951E+02

APPROXIMATE INTEGRATION EMPLOYED FOR SEGMENTS MORE THAN 59.960 METERS APART

- - - MATRIX TIMING - - -

FILL= 13.621 SEC., FACTOR= 0.114 SEC.

- - - ANTENNA INPUT PARAMETERS - - -

TAG	SEG.	VOLTAGE (VOLTS)		CURRENT (AMPS)		IMPEDANCE (OHMS)		ADMITTANCE (MHOS)		POWER
NO.	NO.	REAL	IMAG.	REAL	IMAG.	REAL	IMAG.	REAL	IMAG.	(WATTS)
2	9	0.10000E+01	0.00000E+00	0.89301E-02	-0.35394E-02	0.96778E+02	0.38358E+02	0.89301E-02	-0.35394E-02	0.44651E-02

- - - POWER BUDGET - - -

INPUT POWER = 0.4465E-02 WATTS
RADIATED POWER= 0.4465E-02 WATTS
STRUCTURE LOSS= 0.0000E+00 WATTS
NETWORK LOSS = 0.0000E+00 WATTS
EFFICIENCY = 100.00 PERCENT

- - - RADIATION PATTERNS - - -

- - ANGLES - -		- POWER GAINS -			- - - POLARIZATION - - -			- - - E(THETA) - - -		- - - E(PHI) - --,	
THETA	PHI	VERT.	HOR.	TOTAL	AXIAL	TILT	SENSE	MAGNITUDE	PHASE	MAGNITUDE	PHASE
DEGREES	DEGREES	DB	DB	DB	RATIO	DEG.		VOLTS/M	DEGREES	VOLTS/M	DEGREES
0.00	0.00	-999.99	-999.99	-999.99	0.00000	0.00		0.00000E+00	0.00	0.00000E+00	0.00
5.00	0.00	-23.67	-999.99	-23.67	0.00000	0.00	LINEAR	0.33915E-01	66.61	0.00000E+00	0.00
10.00	0.00	-17.64	-999.99	-17.64	0.00000	0.00	LINEAR	0.67889E-01	66.53	0.00000E+00	0.00
15.00	0.00	-14.11	-999.99	-14.11	0.00000	0.00	LINEAR	0.10195E+00	66.40	0.00000E+00	0.00
20.00	0.00	-11.60	-999.99	-11.60	0.00000	0.00	LINEAR	0.13607E+00	66.22	0.00000E+00	0.00
25.00	0.00	-9.66	-999.99	-9.66	0.00000	0.00	LINEAR	0.17012E+00	65.98	0.00000E+00	0.00
30.00	0.00	-8.09	-999.99	-8.09	0.00000	0.00	LINEAR	0.20387E+00	65.69	0.00000E+00	0.00
35.00	0.00	-6.78	-999.99	-6.78	0.00000	0.00	LINEAR	0.23692E+00	65.33	0.00000E+00	0.00
40.00	0.00	-5.69	-999.99	-5.69	0.00000	0.00	LINEAR	0.26871E+00	64.90	0.00000E+00	0.00
45.00	0.00	-4.78	-999.99	-4.78	0.00000	0.00	LINEAR	0.29849E+00	64.38	0.00000E+00	0.00
50.00	0.00	-4.03	-999.99	-4.03	0.00000	0.00	LINEAR	0.32527E+00	63.75	0.00000E+00	0.00
55.00	0.00	-3.45	-999.99	-3.45	0.00000	0.00	LINEAR	0.34777E+00	62.98	0.00000E+00	0.00
60.00	0.00	-3.05	-999.99	-3.05	0.00000	0.00	LINEAR	0.36435E+00	62.01	0.00000E+00	0.00

65.00	0.00	-2.85	-999.99	-2.85	0.00000	0.00	LINEAR	0.37277E+00	60.75	0.00000E+00	0.00
70.00	0.00	-2.92	-999.99	-2.92	0.00000	0.00	LINEAR	0.36980E+00	59.04	0.00000E+00	0.00
75.00	0.00	-3.39	-999.99	-3.39	0.00000	0.00	LINEAR	0.35013E+00	56.62	0.00000E+00	0.00
80.00	0.00	-4.63	-999.99	-4.63	0.00000	0.00	LINEAR	0.30369E+00	52.91	0.00000E+00	0.00
85.00	0.00	-7.93	-999.99	-7.93	0.00000	0.00	LINEAR	0.20762E+00	46.59	0.00000E+00	0.00
90.00	0.00	-999.99	-999.99	-999.99	0.00000	0.00		0.00000E+00	0.00	0.00000E+00	0.00
0.00	90.00	-999.99	-999.99	-999.99	0.00000	0.00		0.00000E+00	0.00	0.00000E+00	0.00
5.00	90.00	-23.67	-999.99	-23.67	0.00000	0.00	LINEAR	0.33915E-01	66.61	0.00000E+00	0.00
10.00	90.00	-17.64	-999.99	-17.64	0.00000	66.40		0.00000E+00	0.00		
20.00	90.00	-11.60	-999.99	-11.60	0.00000	0.00	LINEAR	0.13607E+00	66.22	0.00000E+00	0.00
25.00	90.00	-9.66	-999.99	-9.66	0.00000	0.00	LINEAR	0.17012E+00	65.98	0.00000E+00	0.00
30.00	90.00	-8.09	-999.99	-8.09	0.00000	0.00	LINEAR	0.20387E+00	65.69	0.00000E+00	0.00
35.00	90.00	-6.78	-999.99	-6.78	0.00000	0.00	LINEAR	0.23692E+00	65.33	0.00000E+00	0.00
40.00	90.00	-5.69	-999.99	-5.69	0.00000	0.00	LINEAR	0.26871E+00	64.90	0.00000E+00	0.00
45.00	90.00	-4.78	-999.99	-4.78	0.00000	0.00	LINEAR	0.29849E+00	64.38	0.00000E+00	0.00
50.00	90.00	-4.03	-999.99	-4.03	0.00000	0.00	LINEAR	0.32527E+00	63.75	0.00000E+00	0.00
55.00	90.00	-3.45	-999.99	-3.45	0.00000	0.00	LINEAR	0.34777E+00	62.98	0.00000E+00	0.00
60.00	90.00	-3.05	-999.99	-3.05	0.00000	0.00	LINEAR	0.36435E+00	62.01	0.00000E+00	0.00
65.00	90.00	-2.85	-999.99	-2.85	0.00000	0.00	LINEAR	0.37277E+00	60.75	0.00000E+00	0.00
70.00	90.00	-2.92	-999.99	-2.92	0.00000	0.00	LINEAR	0.36980E+00	59.04	0.00000E+00	0.00
75.00	90.00	-3.39	-999.99	-3.39	0.00000	0.00	LINEAR	0.35013E+00	56.62	0.00000E+00	0.00
80.00	90.00	-4.63	-999.99	-4.63	0.00000	0.00	LINEAR	0.30369E+00	52.91	0.00000E+00	0.00
85.00	90.00	-7.93	-999.99	-7.93	0.00000	0.00	LINEAR	0.20762E+00	46.59	0.00000E+00	0.00
90.00	90.00	-999.99	-999.99	-999.99	0.00000	0.00		0.00000E+00	0.00	0.00000E+00	0.00

AVERAGE POWER GAIN= 0.32138E+00 SOLID ANGLE USED IN AVERAGING=(0.5000)*PI STERADIANS.

***** DATA CARD NO. 6 NE 0 1 1 21 0.50000E+04 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.1000
0E+02

- - - NEAR ELECTRIC FIELDS - - -

- LOCATION -			- EX -		- EY -		- EZ -		- PEAK FIELD S -
X METERS	Y METERS	Z METERS	MAGNITUDE VOLTS/M	PHASE DEGREES	MAGNITUDE VOLTS/M	PHASE DEGREES	MAGNITUDE VOLTS/M	PHASE DEGREES	MAGNITUDE VOLTS/M
5000.0000	0.0000	0.0000	0.1719E-05	-8.40	0.0000E+00	0.00	0.1054E-04	-45.02	0.1064E-04
5000.0000	0.0000	10.0000	0.1655E-05	-7.39	0.0000E+00	0.00	0.9585E-05	-36.55	0.9694E-05
5000.0000	0.0000	20.0000	0.1593E-05	-6.73	0.0000E+00	0.00	0.8874E-05	-26.93	0.9000E-05
5000.0000	0.0000	30.0000	0.1533E-05	-6.43	0.0000E+00	0.00	0.8448E-05	-16.45	0.8582E-05
5000.0000	0.0000	40.0000	0.1474E-05	-6.50	0.0000E+00	0.00	0.8322E-05	-5.69	0.8452E-05
5000.0000	0.0000	50.0000	0.1418E-05	-6.97	0.0000E+00	0.00	0.8489E-05	4.59	0.8602E-05
5000.0000	0.0000	60.0000	0.1362E-05	-7.86	0.0000E+00	0.00	0.8908E-05	13.79	0.8998E-05
5000.0000	0.0000	70.0000	0.1309E-05	-9.18	0.0000E+00	0.00	0.9530E-05	21.60	0.9596E-05
5000.0000	0.0000	80.0000	0.1257E-05	-10.96	0.0000E+00	0.00	0.1030E-04	27.98	0.1035E-04
5000.0000	0.0000	90.0000	0.1208E-05	-13.24	0.0000E+00	0.00	0.1118E-04	33.05	0.1121E-04
5000.0000	0.0000	100.0000	0.1162E-05	-16.02	0.0000E+00	0.00	0.1212E-04	37.00	0.1214E-04
5000.0000	0.0000	110.0000	0.1119E-05	-19.35	0.0000E+00	0.00	0.1312E-04	40.01	0.1313E-04
5000.0000	0.0000	120.0000	0.1080E-05	-23.22	0.0000E+00	0.00	0.1414E-04	42.26	0.1414E-04
5000.0000	0.0000	130.0000	0.1049E-05	-27.54	0.0000E+00	0.00	0.1518E-04	43.78	0.1519E-04
5000.0000	0.0000	140.0000	0.1022E-05	-32.42	0.0000E+00	0.00	0.1623E-04	44.80	0.1623E-04

5000.0000	0.0000	150.0000	0.9996E-06	-37.95	0.0000E+00	0.00	0.1727E-04	45.40	0.1727E-04
5000.0000	0.0000	160.0000	0.9858E-06	-43.96	0.0000E+00	0.00	0.1830E-04	45.60	0.1830E-04
5000.0000	0.0000	170.0000	0.9809E-06	-50.37	0.0000E+00	0.00	0.1933E-04	45.45	0.1933E-04
5000.0000	0.0000	180.0000	0.9856E-06	-57.07	0.0000E+00	0.00	0.2034E-04	44.99	0.2034E-04
5000.0000	0.0000	190.0000	0.1000E-05	-63.94	0.0000E+00	0.00	0.2134E-04	44.24	0.2134E-04
5000.0000	0.0000	200.0000	0.1026E-05	-70.86	0.0000E+00	0.00	0.2232E-04	43.23	0.2232E-04

```
***** DATA CARD NO.  7   EN   0     0     0     0 0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.0000
0E+00

RUN TIME =    23.501

***** NDP exceptions have occurred during this program. *****

INPUT DATA SET

CM****************************************************************
CM
CM      TEST PROBLEMS FOR THE NEW NEC-3 (NECG ALIAS NPGNEC)
CM
CM****************************************************************
CM
CM      #2 MONOPOLE ANTENNA ON A GROUND STAKE
CM
CE
GW 1,8,0,0,-2,0,0,0,.01
GW 2,10,0,0,0,0,0,15,.01
GP
GE
FR 0,1,0,0,5
GN 2,0,0,0,10,.01
EX 0,2,1
PT -1
RP 0,19,2,1001,0,0,5,90
NE 0,1,1,21,5000,0,0,0,0,10
EN
```

B. 387ROM.OUT (RHOMBIC ANTENNA)

```
*******************************************

  NUMERICAL ELECTROMAGNETICS CODE (NPG1000)

*******************************************


          - - - - COMMENTS - - - -


   TEST OF NPSNEC AS ON C DISK 7 FEB 83
  RHOMBIC ANTENNA HORIZONTALLY POLARIZED
  LEG LENGTH=398.0 FT.
  CENTER WIDTH=314.0 FT.
  APEX ANGLE=44.0 DEGREES.
  HEIGHT ABOVE GROUND=160.0 FT.
  GROUND PARAMETERS-EPSILON=80. SIGMA=4. MHOS/M. (SEA WATER)
  CONDUCTOR-AWG NO. 10 WIRE DIA.=0.00425 FT.


      - - - STRUCTURE SPECIFICATION - - -

          COORDINATES MUST BE INPUT IN
          METERS OR BE SCALED TO METERS
          BEFORE STRUCTURE INPUT IS ENDED


WIRE                                                                 NO. OF   FIRST  LAST    TAG
NO.       X1         Y1         Z1          X2         Y2         Z2      RADIUS  SEG.    SEG.   SEG.    NO.
  1    0.00000    0.00000  160.00000   366.08200  157.00000  160.00000   0.00425    40        1    40      1
  2  366.08200  157.00000  160.00000   732.16400    0.00000  160.00000   0.00425    40       41    80      2
   STRUCTURE REFLECTED ALONG THE AXES   Y  .  TAGS INCREMENTED BY    2
   STRUCTURE SCALED BY FACTOR   0.30480

 GROUND PLANE SPECIFIED.

 WHERE WIRE ENDS TOUCH GROUND, CURRENT WILL BE INTERPOLATED TO IMAGE IN GROUND PLANE.


 TOTAL SEGMENTS USED=  160     NO. SEG. IN A SYMMETRIC CELL=   80     SYMMETRY FLAG=  1
STRUCTURE HAS 1 PLANES OF SYMMETRY


       - MULTIPLE WIRE JUNCTIONS -
JUNCTION    SEGMENTS  (- FOR END 1, + FOR END 2)
 NONE

          - - - - - - FREQUENCY - - - - - -

             FREQUENCY= 0.1000E+02 MHZ
```

WAVELENGTH= 0.2998E+02 METERS

- - - STRUCTURE IMPEDANCE LOADING - - -

LOCATION ITAG	FROM	THRU	RESISTANCE OHMS	INDUCTANCE HENRYS	CAPACITANCE FARADS	IMPEDANCE (OHMS) REAL	IMAGINARY	CONDUCTIVITY MHOS/METER	TYPE
2	40	40	0.3000E+03						SER
4	40	40	0.3000E+03						SER

- - - ANTENNA ENVIRONMENT - - -

FINITE GROUND. REFLECTION COEFFICIENT APPROXIMATION
RELATIVE DIELECTRIC CONST.= 80.000
CONDUCTIVITY= 0.400E+01 MHOS/METER
COMPLEX DIELECTRIC CONSTANT= 0.80000E+02-0.71902E+04

APPROXIMATE INTEGRATION EMPLOYED FOR SEGMENTS MORE THAN 29.980 METERS APART

- - - MATRIX TIMING - - -

FILL= 65.032 SEC., FACTOR= 10.170 SEC.

MAXIMUM RELATIVE ASYMMETRY OF THE DRIVING POINT ADMITTANCE MATRIX IS 0.494E-06 FOR SEGMENTS 81 AND 1
RMS RELATIVE ASYMMETRY IS 0.494E-06

- - - ANTENNA INPUT PARAMETERS - - -

TAG NO.	SEG. NO.	VOLTAGE (VOLTS) REAL	IMAG.	CURRENT (AMPS) REAL	IMAG.	IMPEDANCE (OHMS) REAL	IMAG.	ADMITTANCE (MHOS) REAL	IMAG.	POWER (WATTS)
1	1	0.50000E+00	0.00000E+00	0.11457E-02	-0.55976E-03	0.35232E+03	0.17214E+03	0.22914E-02	-0.11195E-02	0.28642E-03
3	81	-0.50000E+00	0.00000E+00	-0.11457E-02	0.55976E-03	0.35232E+03	0.17214E+03	0.22914E-02	-0.11195E-02	0.28642E-03

- - - POWER BUDGET - - -

INPUT POWER = 0.5728E-03 WATTS
RADIATED POWER= 0.2883E-03 WATTS
STRUCTURE LOSS= 0.2845E-03 WATTS
NETWORK LOSS = 0.0000E+00 WATTS
EFFICIENCY = 50.33 PERCENT

- - - RADIATION PATTERNS - - -

- - ANGLES - -		- POWER GAINS -			- - - POLARIZATION - - -			- - - E(THETA) - - -		- - - E(PHI) - - -	
THETA DEGREES	PHI DEGREES	VERT. DB	HOR. DB	TOTAL DB	AXIAL RATIO	TILT DEG.	SENSE	MAGNITUDE VOLTS/M	PHASE DEGREES	MAGNITUDE VOLTS/M	PHASE DEGREES
90.00	0.00	-999.99	-999.99	-999.99	0.00000	0.00		0.00000E+00	0.00	0.00000E+00	0.00
85.00	0.00	-134.43	15.87	15.87	0.00000	90.00	LINEAR	0.35208E-07	-93.35	0.11516E+01	-32.92
80.00	0.00	-140.55	17.95	17.95	0.00000	90.00	LINEAR	0.17397E-07	-132.94	0.14637E+01	-47.05
75.00	0.00	-137.49	11.26	11.26	0.00000	90.00	LINEAR	0.24754E-07	-58.82	0.67747E+00	-70.40
70.00	0.00	-147.45	6.97	6.97	0.00000	90.00	LINEAR	0.78602E-08	61.43	0.41335E+00	76.28
65.00	0.00	-127.88	11.32	11.32	0.00000	90.00	LINEAR	0.74774E-07	89.84	0.68262E+00	35.77
60.00	0.00	-132.51	2.02	2.02	0.00000	-90.00	LINEAR	0.43873E-07	86.47	0.23391E+00	-11.25
55.00	0.00	-136.10	-22.22	-22.22	0.00000	90.00	LINEAR	0.29041E-07	-65.01	0.14346E-01	-114.92
50.00	0.00	-57.53	-9.31	-9.31	0.00236	-89.82	RIGHT	0.24636E-03	143.82	0.63423E-01	1.60
45.00	0.00	-145.44	5.67	5.67	0.00000	-90.00	LINEAR	0.99120E-08	-164.20	0.35609E+00	-62.49
40.00	0.00	-131.89	0.10597E-01		-35.05	0.35459E-01	158.66				
30.00	0.00	-144.38	-8.90	-8.90	0.00000	90.00	LINEAR	0.11194E-07	-17.54	0.66482E-01	4.91
25.00	0.00	-141.57	-13.08	-13.08	0.00000	-90.00	LINEAR	0.15471E-07	143.54	0.41105E-01	-79.92
20.00	0.00	-143.91	-21.47	-21.47	0.00000	-90.00	LINEAR	0.11821E-07	-104.01	0.15647E-01	9.82
15.00	0.00	-150.61	-27.32	-27.32	0.00000	-90.00	LINEAR	0.54617E-08	83.84	0.79803E-02	-157.15
10.00	0.00	-145.32	-4.71	-4.71	0.00000	90.00	LINEAR	0.10043E-07	124.26	0.10775E+00	123.69
5.00	0.00	-134.67	-9.37	-9.37	0.00000	90.00	LINEAR	0.34233E-07	82.54	0.63001E-01	30.45
0.00	0.00	-137.90	-29.92	-29.92	0.00000	90.00	LINEAR	0.23607E-07	-113.63	0.59130E-02	-179.22
-5.00	0.00	-145.59	-6.52	-6.52	0.00000	-90.00	LINEAR	0.97419E-08	38.81	0.87476E-01	131.57
-10.00	0.00	-144.69	-12.18	-12.18	0.00000	90.00	LINEAR	0.10805E-07	-6.27	0.45587E-01	43.23
-15.00	0.00	-142.56	-36.54	-36.54	0.00000	90.00	LINEAR	0.13796E-07	177.13	0.27589E-02	124.00
-20.00	0.00	-141.33	-21.15	-21.15	0.00000	90.00	LINEAR	0.15894E-07	156.06	0.16237E-01	146.52
-25.00	0.00	-145.26	-23.63	-23.63	0.00000	90.00	LINEAR	0.10117E-07	-143.92	0.12205E-01	-99.45
-30.00	0.00	-157.07	-22.32	-22.32	0.00000	90.00	LINEAR	0.25975E-08	-111.25	0.14187E-01	-116.67
-35.00	0.00	-142.73	-17.09	-17.09	0.00000	90.00	LINEAR	0.13536E-07	-42.80	0.25896E-01	-0.48
-40.00	0.00	-140.47	-8.77	-8.77	0.00000	-90.00	LINEAR	0.17556E-07	73.07	0.67502E-01	-46.52
-45.00	0.00	-141.12	-10.77	-10.77	0.00000	90.00	LINEAR	0.16300E-07	-32.15	0.53660E-01	-74.54
-50.00	0.00	-154.58	-23.24	-23.24	0.00000	-90.00	LINEAR	0.34601E-08	108.38	0.12757E-01	-114.37
-55.00	0.00	-157.24	-44.36	-44.36	0.00000	90.00	LINEAR	0.25472E-08	147.89	0.11213E-02	-177.22
-60.00	0.00	-28.60	-18.55	-18.14	0.07051	72.97	LEFT	0.68873E-02	-171.69	0.21912E-01	-157.49
-65.00	0.00	-31.87	-9.54	-9.52	0.01470	85.71	RIGHT	0.47247E-02	-121.84	0.61763E-01	-132.98
-70.00	0.00	-152.92	-10.36	-10.36	0.00000	90.00	LINEAR	0.41866E-08	164.45	0.56205E-01	-163.64
-75.00	0.00	-150.77	-4.84	-4.84	0.00000	90.00	LINEAR	0.53615E-08	-17.08	0.10618E+00	-12.61
-80.00	0.00	-150.35	2.50	2.50	0.00000	90.00	LINEAR	0.56300E-08	-8.47	0.24712E+00	-35.47
-85.00	0.00	-163.57	0.73	0.73	0.00000	90.00	LINEAR	0.12282E-08	-84.24	0.20168E+00	-49.54
-90.00	0.00	-999.99	-999.99	-999.99	0.00000	0.00		0.00000E+00	0.00	0.00000E+00	0.00

- - - - NORMALIZED GAIN - - - -

HORIZONTAL GAIN
NORMALIZATION FACTOR = 17.95 DB

- - ANGLES - -		GAIN	- - ANGLES - -		GAIN	- - ANGLES - -		GAIN
THETA DEGREES	PHI DEGREES	DB	THETA DEGREES	PHI DEGREES	DB	THETA DEGREES	PHI DEGREES	DB
90.00	0.00	-1017.94	25.00	0.00	-31.03	-35.00	0.00	-35.04

85.00	0.00	-2.08	20.00	0.00	-39.42	-40.00	0.00	-26.72
80.00	0.00	0.00	15.00	0.00	-45.27	-45.00	0.00	-28.72
75.00	0.00	-6.69	10.00	0.00	-22.66	-50.00	0.00	-41.19
70.00	0.00	-10.98	5.00	0.00	-27.32	-55.00	0.00	-62.31
65.00	0.00	-6.63	0.00	0.00	-47.87	-60.00	0.00	-36.50
60.00	0.00	-15.93	-5.00	0.00	-24.47	-65.00	0.00	-27.49
55.00	0.00	-40.17	-10.00	0.00	-30.13	-70.00	0.00	-28.31
50.00	0.00	-27.26	-15.00	0.00	-54.49	-75.00	0.00	-22.79
45.00	0.00	-12.28	-20.00	0.00	-39.10	-80.00	0.00	-15.45
40.00	0.00	-13.79	-25.00	0.00	-41.58	-85.00	0.00	-17.22
35.00	0.00	-32.31	-30.00	0.00	-40.27	-90.00	0.00	-1017.94
30.00	0.00	-26.86						

```
***** DATA CARD NO. 10   EN   0     0     0     0  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.0000
0E+00

RUN TIME =    99.150

***** NDP exceptions have occurred during this program. *****

CM   TEST OF NPSNEC AS ON C DISK 7 FEB 83
CM RHOMBIC ANTENNA HORIZONTALLY POLARIZED
CM LEG LENGTH=398.0 FT.
CM CENTER WIDTH=314.0 FT.
CM APEX ANGLE=44.0 DEGREES.
CM HEIGHT ABOVE GROUND=160.0 FT.
CM GROUND PARAMETERS-EPSILON=80. SIGMA=4. MHOS/M. (SEA WATER)
CE CONDUCTOR-AWG NO. 10 WIRE DIA.=0.00425 FT.
GW1,40,0.0,0.0,160.0,366.082,157.0,160.0,0.00425
GW2,40,366.082,157.0,160.0,732.164,0.0,160.0,0.00425
GX2,010
GS0,0,0.304801
GP
GE1
FR0,0,0,0,10.0
GN0,0,0,0,80.0,4.0
LD0,2,40,40,300.0
LD0,4,40,40,300.0
EX0,1,1,0,0.5
PT -1
EX0,3,1,10,-0.5
PT -1
RP0,37,1,1401,90.0,0.0,-5.0,0.0
EN
```

C. 387DP49.OUT (49 SEGMENT CENTER FED DIPOLE)

```
                    ********************************************

                      NUMERICAL ELECTROMAGNETICS CODE (NFG1000)

                    ********************************************


                          - - - - COMMENTS - - - -


               DIPOLE WITH 49 SEGMENTS


                  - - - STRUCTURE SPECIFICATION - - -

                      COORDINATES MUST BE INPUT IN
                      METERS OR BE SCALED TO METERS
                      BEFORE STRUCTURE INPUT IS ENDED


 WIRE                                                             NO. OF    FIRST  LAST     TAG
 NO.       X1         Y1         Z1         X2         Y2         Z2      RADIUS   SEG.     SEG.  SEG.     NO.
   1    0.00000    0.00000    0.00000    0.00000    0.00000    0.50000   0.00001    49        1    49        1

  TOTAL SEGMENTS USED=   49     NO. SEG. IN A SYMMETRIC CELL=   49     SYMMETRY FLAG=  0


      - MULTIPLE WIRE JUNCTIONS -
 JUNCTION    SEGMENTS  (- FOR END 1, + FOR END 2)
 NONE

                    - - - - - - FREQUENCY - - - - - -

                      FREQUENCY= 0.2998E+03 MHZ
                      WAVELENGTH= 0.1000E+01 METERS


                   - - - STRUCTURE IMPEDANCE LOADING - - -

                     THIS STRUCTURE IS NOT LOADED


                    - - - ANTENNA ENVIRONMENT - - -

                             FREE SPACE


          APPROXIMATE INTEGRATION EMPLOYED FOR SEGMENTS MORE THAN   1.000 METERS APART
```

```
                    - - - MATRIX TIMING - - -

              FILL=   12.410 SEC.,  FACTOR=    1.040 SEC.


                              - - - ANTENNA INPUT PARAMETERS - - -

 TAG   SEG.    VOLTAGE (VOLTS)          CURRENT (AMPS)          IMPEDANCE (OHMS)         ADMITTANCE (MHOS)       POWER
 NO.   NO.    REAL        IMAG.        REAL        IMAG.        REAL        IMAG.        REAL        IMAG.      (WATTS)
   1    25 0.10000E+01 0.00000E+00 0.95248E-02-0.56000E-02 0.78020E+02 0.45871E+02 0.95248E-02-0.56000E-02 0.47624E-02


                             - - - POWER BUDGET - - -

                               INPUT POWER   = 0.4762E-02 WATTS
                               RADIATED POWER= 0.4762E-02 WATTS
                               STRUCTURE LOSS= 0.0000E+00 WATTS
                               NETWORK LOSS  = 0.0000E+00 WATTS
                               EFFICIENCY    = 100.00 PERCENT


***** DATA CARD NO.  4   EN   0     0     0     0  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.0000
0E+00

RUN TIME =    14.109

***** NDP exceptions have occurred during this program. *****

INPUT DATA FILE

CE   DIPOLE WITH 49 SEGMENTS
GW 1,49,0.0,0,0,0,0,.5,.00001
GP
GE
EX 0,1,25
PT -1
XQ
EN
```

APPENDIX J. NEC3 SAMPLE RUNS ON COMPAQ 386/20 (WIETEK 1167)

A. 1167G2.OUT (MONOPOLE WITH LOSSY GROUND, REQUIRES SOMNTX DATA)

```
            ****************************************

             NUMERICAL ELECTROMAGNETICS CODE (NPGI000)

            ****************************************



                 - - - - COMMENTS - - - -


    **********************************************************

       TEST PROBLEMS FOR THE NEW NEC-3 (NECG ALIAS NPGNEC)

    **********************************************************

       #2 MONOPOLE ANTENNA ON A GROUND STAKE


            - - - STRUCTURE SPECIFICATION - - -

              COORDINATES MUST BE INPUT IN
              METERS OR BE SCALED TO METERS
              BEFORE STRUCTURE INPUT IS ENDED


WIRE                                                                      NO. OF    FIRST  LAST     TAG
NO.       X1         Y1         Z1          X2         Y2         Z2       RADIUS   SEG.     SEG.   SEG.     NO.
  1    0.00000    0.00000   -2.00000     0.00000    0.00000    0.00000    0.01000     8         1     8      1
  2    0.00000    0.00000    0.00000     0.00000    0.00000   15.00000    0.01000    10         9    18      2

 TOTAL SEGMENTS USED=   18     NO. SEG. IN A SYMMETRIC CELL=   18     SYMMETRY FLAG=  0


      - MULTIPLE WIRE JUNCTIONS -
JUNCTION    SEGMENTS  (- FOR END 1, + FOR END 2)
 NONE

            - - - - - - FREQUENCY - - - - - -

              FREQUENCY= 0.5000E+01 MHZ
              WAVELENGTH= 0.5996E+02 METERS


          - - - STRUCTURE IMPEDANCE LOADING - - -

             THIS STRUCTURE IS NOT LOADED
```

- - - ANTENNA ENVIRONMENT - - -

FINITE GROUND. SOMMERFELD SOLUTION
RELATIVE DIELECTRIC CONST.= 10.000
CONDUCTIVITY= 0.100E-01 MHOS/METER
COMPLEX DIELECTRIC CONSTANT= 0.10000E+02-0.35951E+02

APPROXIMATE INTEGRATION EMPLOYED FOR SEGMENTS MORE THAN 59.960 METERS APART

An NDP exception has occurred.
Near location c:6c0f2.

Weitek status word = 03fec027.
/Invalid operation./Zero divide./Precision./

NS - THETA DEGREES	PHI DEGREES	- - - POLARIZATION - - - VERT. DB	HOR. DB	TOTAL DB	- - - E(THETA) - - - AXIAL RATIO	TILT DEG.	SENSE	- - - E(PHI) - --, MAGNITUDE VOLTS/M	PHASE DEGREES	MAGNITUDE VOLTS/M	PHASE DEGREES
0.00	0.00	-999.99	-999.99	-999.99	0.00000	0.00		0.00000E+00	0.00	0.00000E+00	0.00
5.00	0.00	-23.67	-999.99	-23.67	0.00000	0.00	LINEAR	0.33912E-01	66.61	0.00000E+00	0.00
10.00	0.00	-17.64	-999.99	-17.64	0.00000	0.00	LINEAR	0.67885E-01	66.53	0.00000E+00	0.00
15.00	0.00	-14.11	-999.99	-14.11	0.00000	0.00	LINEAR	0.10195E+00	66.40	0.00000E+00	0.00
20.00	0.00	-11.60	-999.99	-11.60	0.00000	0.00	LINEAR	0.13606E+00	66.22	0.00000E+00	0.00
25.00	0.00	-9.66	-999.99	-9.66	0.00000	0.00	LINEAR	0.17011E+00	65.99	0.00000E+00	0.00
30.00	0.00	-8.09	-999.99	-8.09	0.00000	0.00	LINEAR	0.20385E+00	65.69	0.00000E+00	0.00
35.00	0.00	-6.79	-999.99	-6.79	0.00000	0.00	LINEAR	0.23690E+00	65.33	0.00000E+00	0.00
40.00	0.00	-5.69	-999.99	-5.69	0.00000	0.00	LINEAR	0.26869E+00	64.90	0.00000E+00	0.00
45.00	0.00	-4.78	-999.99	-4.78	0.00000	0.00	LINEAR	0.29847E+00	64.38	0.00000E+00	0.00
50.00	0.00	-4.03	-999.99	-4.03	0.00000	0.00	LINEAR	0.32525E+00	63.75	0.00000E+00	0.00
55.00	0.00	-3.45	-999.99	-3.45	0.00000	0.00	LINEAR	0.34775E+00	62.98	0.00000E+00	0.00
60.00	0.00	-3.05	-999.99	-3.05	0.00000	0.00	LINEAR	0.36432E+00	62.01	0.00000E+00	0.00
65.00	0.00	-2.85	-999.99	-2.85	0.00000	0.00	LINEAR	0.37275E+00	60.75	0.00000E+00	0.00
70.00	0.00	-2.92	-999.99	-2.92	0.00000	0.00	LINEAR	0.36978E+00	59.05	0.00000E+00	0.00
75.00	0.00	-3.39	-999.99	-3.39	0.00000	0.00	LINEAR	0.35011E+00	56.62	0.00000E+00	0.00
80.00	0.00	-4.63	-999.99	-4.63	0.00000	0.00	LINEAR	0.30367E+00	52.91	0.00000E+00	0.00
85.00	0.00	-7.93	-999.99	-7.93	0.00000	0.00	LINEAR	0.20761E+00	46.60	0.00000E+00	0.00
90.00	0.00	-999.99	-999.99	-999.99	0.00000	0.00		0.00000E+00	0.00	0.00000E+00	0.00
0.00	90.00	-999.99	-999.99	-999.99	0.00000	0.00		0.00000E+00	0.00	0.00000E+00	180.00
5.00	90.00	-23.67	-999.99	-23.67	0.00000	0.00	LINEAR	0.33912E-01	66.61	0.00000E+00	180.00
10.00	90.00	-17.64	-999.99	-17.64	0.90000	66.40	0.00000E+00	180.00			
20.00	90.00	-11.60	-999.99	-11.60	0.00000	0.00	LINEAR	0.13606E+00	66.22	0.00000E+00	180.00
25.00	90.00	-9.66	-999.99	-9.66	0.00000	0.00	LINEAR	0.17011E+00	65.99	0.00000E+00	180.00
30.00	90.00	-8.09	-999.99	-8.09	0.00000	0.00	LINEAR	0.20385E+00	65.69	0.00000E+00	180.00
35.00	90.00	-6.79	-999.99	-6.79	0.00000	0.00	LINEAR	0.23690E+00	65.33	0.00000E+00	180.00
40.00	90.00	-5.69	-999.99	-5.69	0.00000	0.00	LINEAR	0.26869E+00	64.90	0.00000E+00	180.00
45.00	90.00	-4.78	-999.99	-4.78	0.00000	0.00	LINEAR	0.29847E+00	64.38	0.00000E+00	180.00
50.00	90.00	-4.03	-999.99	-4.03	0.00000	0.00	LINEAR	0.32525E+00	63.75	0.00000E+00	180.00
55.00	90.00	-3.45	-999.99	-3.45	0.00000	0.00	LINEAR	0.34775E+00	62.98	0.00000E+00	180.00
60.00	90.00	-3.05	-999.99	-3.05	0.00000	0.00	LINEAR	0.36432E+00	62.01	0.00000E+00	180.00

65.00	90.00	-2.85	-999.99	-2.85	0.00000	0.00	LINEAR	0.37275E+00	60.75	0.00000E+00	180.00
70.00	90.00	-2.92	-999.99	-2.92	0.00000	0.00	LINEAR	0.36978E+00	59.05	0.00000E+00	180.00
75.00	90.00	-3.39	-999.99	-3.39	0.00000	0.00	LINEAR	0.35011E+00	56.62	0.00000E+00	180.00
80.00	90.00	-4.63	-999.99	-4.63	0.00000	0.00	LINEAR	0.30367E+00	52.91	0.00000E+00	180.00
85.00	90.00	-7.93	-999.99	-7.93	0.00000	0.00	LINEAR	0.20761E+00	46.60	0.00000E+00	180.00
90.00	90.00	-999.99	-999.99	-999.99	0.00000	0.00		0.00000E+00	0.00	0.00000E+00	0.00

AVERAGE POWER GAIN= 0.32135E+00 SOLID ANGLE USED IN AVERAGING=(0.5000)*PI STERADIANS.

***** DATA CARD NO. 6 NE 0 1 1 21 0.50000E+04 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.1000
0E+02

- - - NEAR ELECTRIC FIELDS - - -

- LOCATION -			- EX -		- EY -		- EZ -		- PEAK FIELDS -
X METERS	Y METERS	Z METERS	MAGNITUDE VOLTS/M	PHASE DEGREES	MAGNITUDE VOLTS/M	PHASE DEGREES	MAGNITUDE VOLTS/M	PHASE DEGREES	MAGNITUDE VOLTS/M
5000.0000	0.0000	0.0000	0.1719E-05	-8.39	0.0000E+00	0.00	0.1054E-04	-45.01	0.1064E-04
5000.0000	0.0000	10.0000	0.1655E-05	-7.39	0.0000E+00	0.00	0.9585E-05	-36.54	0.9694E-05
5000.0000	0.0000	20.0000	0.1593E-05	-6.73	0.0000E+00	0.00	0.8876E-05	-26.91	0.9001E-05
5000.0000	0.0000	30.0000	0.1533E-05	-6.43	0.0000E+00	0.00	0.8449E-05	-16.43	0.8583E-05
5000.0000	0.0000	40.0000	0.1474E-05	-6.50	0.0000E+00	0.00	0.8325E-05	-5.68	0.8455E-05
5000.0000	0.0000	50.0000	0.1417E-05	-6.97	0.0000E+00	0.00	0.8491E-05	4.60	0.8604E-05
5000.0000	0.0000	60.0000	0.1362E-05	-7.85	0.0000E+00	0.00	0.8911E-05	13.80	0.9000E-05
5000.0000	0.0000	70.0000	0.1309E-05	-9.18	0.0000E+00	0.00	0.9531E-05	21.60	0.9597E-05
5000.0000	0.0000	80.0000	0.1257E-05	-10.96	0.0000E+00	0.00	0.1030E-04	27.98	0.1035E-04
5000.0000	0.0000	90.0000	0.1208E-05	-13.23	0.0000E+00	0.00	0.1118E-04	33.05	0.1121E-04
5000.0000	0.0000	100.0000	0.1162E-05	-16.02	0.0000E+00	0.00	0.1213E-04	37.00	0.1215E-04
5000.0000	0.0000	110.0000	0.1119E-05	-19.35	0.0000E+00	0.00	0.1312E-04	40.01	0.1313E-04
5000.0000	0.0000	120.0000	0.1080E-05	-23.22	0.0000E+00	0.00	0.1414E-04	42.25	0.1415E-04
5000.0000	0.0000	130.0000	0.1048E-05	-27.53	0.0000E+00	0.00	0.1518E-04	43.77	0.1519E-04
5000.0000	0.0000	140.0000	0.1021E-05	-32.42	0.0000E+00	0.00	0.1623E-04	44.79	0.1623E-04
5000.0000	0.0000	150.0000	0.9994E-06	-37.95	0.0000E+00	0.00	0.1727E-04	45.40	0.1727E-04
5000.0000	0.0000	160.0000	0.9856E-06	-43.96	0.0000E+00	0.00	0.1830E-04	45.60	0.1830E-04
5000.0000	0.0000	170.0000	0.9808E-06	-50.37	0.0000E+00	0.00	0.1932E-04	45.45	0.1932E-04
5000.0000	0.0000	180.0000	0.9855E-06	-57.07	0.0000E+00	0.00	0.2034E-04	44.98	0.2034E-04
5000.0000	0.0000	190.0000	0.1000E-05	-63.94	0.0000E+00	0.00	0.2134E-04	44.23	0.2134E-04
5000.0000	0.0000	200.0000	0.1026E-05	-70.86	0.0000E+00	0.00	0.2232E-04	43.23	0.2232E-04

***** DATA CARD NO. 7 EN 0 0 0 0 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.0000
0E+00

RUN TIME = 11.211

INPUT DATA SET

CM**
CM
CM TEST PROBLEMS FOR THE NEW NEC-3 (NEC3 ALIAS MPGNEC)

```
CM
CM*******************************************************************
CM
CM      #2 MONOPOLE ANTENNA ON A GROUND STAKE
CM
CE
GW 1,8,0,0,-2,0,0,0,.01
GW 2,10,0,0,0,0,0,15,.01
GP
GE
FR 0,1,0,0,5
GN 2,0,0,0,10,.01
EX 0,2,1
PT -1
RP 0,19,2,1001,0,0,5,90
NE 0,1,1,21,5000,0,0,0,0,10
EN
```

B. 1167ROM.OUT (RHOMBIC ANTENNA)

```
********************************************

  NUMERICAL ELECTROMAGNETICS CODE (NPGI000)

********************************************


            - - - - COMMENTS - - - -


     TEST OF NPSNEC AS ON C DISK 7 FEB 83
     RHOMBIC ANTENNA HORIZONTALLY POLARIZED
     LEG LENGTH=398.0 FT.
     CENTER WIDTH=314.0 FT.
     APEX ANGLE=44.0 DEGREES.
     HEIGHT ABOVE GROUND=160.0 FT.
     GROUND PARAMETERS-EPSILON=80. SIGMA=4. MHOS/M. (SEA WATER)
     CONDUCTOR-AWG NO. 10 WIRE DIA.=0.00425 FT.


          - - - STRUCTURE SPECIFICATION - - -

            COORDINATES MUST BE INPUT IN
            METERS OR BE SCALED TO METERS
            BEFORE STRUCTURE INPUT IS ENDED


WIRE                                                                    NO. OF   FIRST  LAST    TAG
NO.      X1         Y1         Z1         X2         Y2         Z2      RADIUS   SEG.    SEG.   SEG.    NO.
  1   0.00000    0.00000  160.00000  366.08200  157.00000  160.00000   0.00425    40       1     40      1
  2 366.08200  157.00000  160.00000  732.16400    0.00000  160.00000   0.00425    40      41     80      2
   STRUCTURE REFLECTED ALONG THE AXES  Y  . TAGS INCREMENTED BY   2
   STRUCTURE SCALED BY FACTOR   0.30480

 GROUND PLANE SPECIFIED.

 WHERE WIRE ENDS TOUCH GROUND, CURRENT WILL BE INTERPOLATED TO IMAGE IN GROUND PLANE.


 TOTAL SEGMENTS USED=  160     NO. SEG. IN A SYMMETRIC CELL=   80     SYMMETRY FLAG=  1
STRUCTURE HAS 1 PLANES OF SYMMETRY



      - MULTIPLE WIRE JUNCTIONS -
JUNCTION    SEGMENTS  (- FOR END 1, + FOR END 2)
 NONE


          - - - - - - FREQUENCY - - - - - -
```

FREQUENCY= 0.1000E+02 MHZ
WAVELENGTH= 0.2998E+02 METERS

- - - STRUCTURE IMPEDANCE LOADING - - -

LOCATION			RESISTANCE	INDUCTANCE	CAPACITANCE	IMPEDANCE (OHMS)		CONDUCTIVITY	TYPE
ITAG	FROM	THRU	OHMS	HENRYS	FARADS	REAL	IMAGINARY	MHOS/METER	
2	40	40	0.3000E+03						SER
4	40	40	0.3000E+03						SER

- - - ANTENNA ENVIRONMENT - - -

FINITE GROUND. REFLECTION COEFFICIENT APPROXIMATION
RELATIVE DIELECTRIC CONST.= 80.000
CONDUCTIVITY= 0.400E+01 MHOS/METER
COMPLEX DIELECTRIC CONSTANT= 0.80000E+02-0.71902E+04

APPROXIMATE INTEGRATION EMPLOYED FOR SEGMENTS MORE THAN 29.980 METERS APART

- - - MATRIX TIMING - - -

FILL= 25.539 SEC., FACTOR= 3.617 SEC.

MAXIMUM RELATIVE ASYMMETRY OF THE DRIVING POINT ADMITTANCE MATRIX IS 0.000E+00 FOR SEGMENTS 81 AND 1
RMS RELATIVE ASYMMETRY IS 0.000E+00

- - - ANTENNA INPUT PARAMETERS - - -

TAG	SEG.	VOLTAGE (VOLTS)		CURRENT (AMPS)		IMPEDANCE (OHMS)		ADMITTANCE (MHOS)		POWER
NO.	NO.	REAL	IMAG.	REAL	IMAG.	REAL	IMAG.	REAL	IMAG.	(WATTS)
1	1	0.50000E+00	0.00000E+00	0.11464E-02	-0.56029E-03	0.35205E+03	0.17206E+03	0.22928E-02	-0.11206E-02	0.28660E-03
3	81	-0.50000E+00	0.00000E+00	-0.11464E-02	0.56029E-03	0.35205E+03	0.17206E+03	0.22928E-02	-0.11206E-02	0.28660E-03

- - - POWER BUDGET - - -

INPUT POWER = 0.5732E-03 WATTS

RADIATED POWER= 0.2881E-03 WATTS
STRUCTURE LOSS= 0.2851E-03 WATTS
NETWORK LOSS = 0.0000E+00 WATTS
EFFICIENCY = 50.27 PERCENT

- - - RADIATION PATTERNS - - -

- - ANGLES - -		- POWER GAINS -			- - - POLARIZATION - - -			- - - E(THETA) - - -		- - - E(PHI) - - -,	
THETA DEGREES	PHI DEGREES	VERT. DB	HOR. DB	TOTAL DB	AXIAL RATIO	TILT DEG.	SENSE	MAGNITUDE VOLTS/M	PHASE DEGREES	MAGNITUDE VOLTS/M	PHASE DEGREES
90.00	0.00	-999.99	-999.99	-999.99	0.00000	0.00		0.00000B+00	0.00	0.00000B+00	0.00
85.00	0.00	-140.50	15.87	15.87	0.00000	90.00	LINEAR	0.17503E-07	11.56	0.11523E+01	-32.92
80.00	0.00	-137.47	17.95	17.95	0.00000	-90.00	LINEAR	0.24814E-07	-176.48	0.14646B+01	-47.05
75.00	0.00	-139.05	11.26	11.26	0.00000	-90.00	LINEAR	0.20683E-07	66.25	0.67789E+00	-70.41
70.00	0.00	-154.45	6.97	6.97	0.00000	90.00	LINEAR	0.35113E-08	-4.09	0.41361B+00	76.27
65.00	0.00	-137.31	11.33	11.33	0.00000	90.00	LINEAR	0.25261E-07	-4.21	0.68304E+00	35.76
60.00	0.00	-133.32	2.02	2.02	0.00000	-90.00	LINEAR	0.40011E-07	-126.45	0.23405E+00	-11.28
55.00	0.00	-134.54	-22.22	-22.22	0.00000	-90.00	LINEAR	0.34768E-07	70.25	0.14354E-01	-114.87
50.00	0.00	-153.34	-9.30	-9.30	0.00000	90.00	LINEAR	0.39894E-08	45.00	0.63580B-01	1.53
45.00	0.00	-133.68	5.67	5.67	0.00000	90.00	LINEAR	0.38373E-07	-123.32	0.35628E+00	-62.49
40.00	0.00	-133.30	0.30809E-07		-76.50	0.30060E-01	161.08				
30.00	0.00	-136.52	-8.90	-8.90	0.00000	-90.00	LINEAR	0.27671E-07	-123.33	0.66518E-01	4.93
25.00	0.00	-148.40	-13.08	-13.08	0.00000	90.00	LINEAR	0.70468B-08	-48.81	0.41127B-01	-79.92
20.00	0.00	-147.55	-21.47	-21.47	0.00000	-90.00	LINEAR	0.77762E-08	135.00	0.15652E-01	9.80
15.00	0.00	-143.78	-27.33	-27.33	0.00000	-90.00	LINEAR	0.11995B-07	76.37	0.79745E-02	-157.08
10.00	0.00	-141.12	-4.71	-4.71	0.00000	90.00	LINEAR	0.16299E-07	135.00	0.10780E+00	123.69
5.00	0.00	-143.62	-9.37	-9.37	0.00000	-90.00	LINEAR	0.12215B-07	-72.65	0.63009E-01	30.43
0.00	0.00	-140.04	-29.92	-29.92	0.00000	-90.00	LINEAR	0.18450E-07	76.24	0.59149E-02	-179.21
-5.00	0.00	-151.21	-6.52	-6.52	0.00000	-90.00	LINEAR	0.51006B-08	-90.00	0.87510B-01	131.57
-10.00	0.00	-143.87	-12.18	-12.18	0.00000	90.00	LINEAR	0.11880E-07	14.04	0.45587E-01	43.21
-15.00	0.00	-147.37	-36.54	-36.54	0.00000	90.00	LINEAR	0.79385B-08	159.15	0.27611E-02	124.01
-20.00	0.00	-149.59	-21.15	-21.15	0.00000	-90.00	LINEAR	0.61477E-08	-63.43	0.16240E-01	146.54
-25.00	0.00	-147.57	-23.63	-23.63	0.00000	90.00	LINEAR	0.77592E-08	-70.02	0.12202B-01	-99.44
-30.00	0.00	-147.96	-22.32	-22.32	0.00000	-90.00	LINEAR	0.74143E-08	70.02	0.14185E-01	-116.58
-35.00	0.00	-145.66	-17.10	-17.10	0.00000	-90.00	LINEAR	0.96612B-08	-150.26	0.25896E-01	-0.47
-40.00	0.00	-146.52	-8.78	-8.78	0.00000	90.00	LINEAR	0.87524E-08	-50.19	0.67487E-01	-46.48
-45.00	0.00	-143.39	-10.77	-10.77	0.00000	-90.00	LINEAR	0.12544E-07	165.68	0.53661B-01	-74.47
-50.00	0.00	-147.08	-23.24	-23.24	0.00000	90.00	LINEAR	0.82009E-08	-62.70	0.12762E-01	-114.30
-55.00	0.00	-146.63	-44.48	-44.48	0.00000	90.00	LINEAR	0.86388B-08	119.05	0.11072E-02	-177.38
-60.00	0.00	-151.82	-21.16	-21.16	0.00000	90.00	LINEAR	0.47544E-08	157.38	0.16223E-01	-151.98
-65.00	0.00	-152.04	-8.60	-8.60	0.00000	90.00	LINEAR	0.46368E-08	-126.87	0.68910E-01	-132.69
-70.00	0.00	-146.81	-10.35	-10.35	0.00000	90.00	LINEAR	0.84651E-08	108.97	0.56301E-01	-163.56
-75.00	0.00	-154.70	-4.83	-4.83	0.00000	-90.00	LINEAR	0.34128B-08	-176.82	0.10632E+00	-12.54
-80.00	0.00	-155.62	2.51	2.51	0.00000	-90.00	LINEAR	0.30694E-08	-155.56	0.24738E+00	-35.40
-85.00	0.00	-159.48	0.74	0.74	0.00000	-90.00	LINEAR	0.19690B-08	119.05	0.20187B+00	-49.46
-90.00	0.00	-999.99	-999.99	-999.99	0.00000	0.00		0.00000E+00	0.00	0.00000E+00	0.00

- - - - NORMALIZED GAIN - - - -

HORIZONTAL GAIN
NORMALIZATION FACTOR = 17.95 DB

- - ANGLES - -		GAIN	- - ANGLES - -		GAIN	- - ANGLES - -		GAIN
THETA	PHI	DB	THETA	PHI	DB	THETA	PHI	DB
DEGREES	DEGREES		DEGREES	DEGREES		DEGREES	DEGREES	
90.00	0.00	-1017.94	25.00	0.00	-31.03	-35.00	0.00	-35.05
85.00	0.00	-2.08	20.00	0.00	-39.42	-40.00	0.00	-26.73
80.00	0.00	0.00	15.00	0.00	-45.28	-45.00	0.00	-28.72
75.00	0.00	-6.69	10.00	0.00	-22.66	-50.00	0.00	-41.20
70.00	0.00	-10.98	5.00	0.00	-27.33	-55.00	0.00	-62.43
65.00	0.00	-6.63	0.00	0.00	-47.88	-60.00	0.00	-39.11
60.00	0.00	-15.93	-5.00	0.00	-24.47	-65.00	0.00	-26.55
55.00	0.00	-40.18	-10.00	0.00	-30.14	-70.00	0.00	-28.30
50.00	0.00	-27.25	-15.00	0.00	-54.49	-75.00	0.00	-22.78
45.00	0.00	-12.28	-20.00	0.00	-39.10	-80.00	0.00	-15.45
40.00	0.00	-13.79	-25.00	0.00	-41.59	-85.00	0.00	-17.21
35.00	0.00	-33.75	-30.00	0.00	-40.28	-90.00	0.00	-1017.94
30.00	0.00	-26.86						

```
***** DATA CARD NO. 10   EN   0     0     0     0  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.0000
0E+00

RUN TIME =     38.344

INPUT DATA SET


CM   TEST OF NPSNEC AS ON C DISK 7 FEB 83
CM RHOMBIC ANTENNA HORIZONTALLY POLARIZED
CM LEG LENGTH=398.0 FT.
CM CENTER WIDTH=314.0 FT.
CM APEX ANGLE=44.0 DEGREES.
CM HEIGHT ABOVE GROUND=160.0 FT.
CM GROUND PARAMETERS-EPSILON=80. SIGMA=4. MHOS/M. (SEA WATER)
CE CONDUCTOR-AWG NO. 10 WIRE DIA.=0.00425 FT.
GW1.40,0.0,0.0,160.0,366.082,157.0,160.0,0.00425
GW2.40,366.082,157.0,160.0,732.164,0.0,160.0,0.00425
GX2.010
GS0,0,0.304801
GP
GE1
FR0,0,0,0,10.0
GN0,0,0,0,80.0,4.0
LD0,2,40,40,300.0
LD0,4,40,40,300.0
EX0,1,1,0,0.5
PT -1
EX0,3,1,10,-0.5
PT -1
RP0,37,1,1401,90.0,0.0,-5.0,0.0
EN
```

C. 1167DP49.OUT (49 SEGMENT CENTER FED DIPOLE)

```
          ***********************************************

           NUMERICAL ELECTROMAGNETICS CODE (NPGI000)

          ***********************************************


                    - - - - COMMENTS - - - -


          DIPOLE WITH 49 SEGMENTS


               - - - STRUCTURE SPECIFICATION - - -

                    COORDINATES MUST BE INPUT IN
                    METERS OR BE SCALED TO METERS
                    BEFORE STRUCTURE INPUT IS ENDED
```

WIRE NO.	X1	Y1	Z1	X2	Y2	Z2	RADIUS	NO. OF SEG.	FIRST SEG.	LAST SEG.	TAG NO.
1	0.00000	0.00000	0.00000	0.00000	0.00000	0.50000	0.00001	49	1	49	1

```
 TOTAL SEGMENTS USED=   49     NO. SEG. IN A SYMMETRIC CELL=   49     SYMMETRY FLAG=  0


      - MULTIPLE WIRE JUNCTIONS -
JUNCTION    SEGMENTS  (- FOR END 1, + FOR END 2)
 NONE

               - - - - - - FREQUENCY - - - - - -

                  FREQUENCY= 0.2998E+03 MHZ
                  WAVELENGTH= 0.1000E+01 METERS


              - - - STRUCTURE IMPEDANCE LOADING - - -

                  THIS STRUCTURE IS NOT LOADED


                  - - - ANTENNA ENVIRONMENT - - -

                          FREE SPACE
```

```
APPROXIMATE INTEGRATION EMPLOYED FOR SEGMENTS MORE THAN   1.000 METERS APART


                  - - - MATRIX TIMING - - -

              FILL=    5.047 SEC.,  FACTOR=    0.445 SEC.


                          - - - ANTENNA INPUT PARAMETERS - - -

 TAG  SEG.    VOLTAGE (VOLTS)         CURRENT (AMPS)         IMPEDANCE (OHMS)        ADMITTANCE (MHOS)      POWER
 NO.  NO.    REAL        IMAG.       REAL         IMAG.       REAL        IMAG.       REAL         IMAG.     (WATTS)
   1    25 0.10000E+01 0.00000E+00 0.97680E-02-0.54736E-02 0.77911E+02 0.43658E+02 0.97680E-02-0.54736E-02 0.48840E-02


                         - - - POWER BUDGET - - -

                           INPUT POWER    = 0.4884E-02 WATTS
                           RADIATED POWER= 0.4884E-02 WATTS
                           STRUCTURE LOSS= 0.0000E+00 WATTS
                           NETWORK LOSS  = 0.0000E+00 WATTS
                           EFFICIENCY    = 100.00 PERCENT

***** DATA CARD NO.  4   EN   0     0     0     0  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.0000
0E+00

RUN TIME =     5.883

INPUT DATA FILE

CE   DIPOLE WITH 49 SEGMENTS
GW 1,49,0,0,0,0,0,.5,.00001
GP
GE
EX 0,1,25
PT -1
XQ
EN
```

APPENDIX K. NEC3 SAMPLE RUNS ON IBM 3033AP MAINFRAME

A. NPSG2.OUT (MONOPOLE WITH LOSSY GROUND, REQUIRES SOMNTX DATA)

```
                    ********************************************

                     NUMERICAL ELECTROMAGNETICS CODE - DNPGNEC

                    ********************************************


                           - - - - COMMENTS - - - -


                TEST G2

                MONOPOLE ANTENNA ON A GROUND STAKE


                       - - - STRUCTURE SPECIFICATION - - -

                           COORDINATES MUST BE INPUT IN
                           METERS OR BE SCALED TO METERS
                           BEFORE STRUCTURE INPUT IS ENDED


WIRE                                                                        NO. OF    FIRST  LAST     TAG
NO.       X1        Y1        Z1          X2        Y2        Z2      RADIUS  SEG.     SEG.   SEG.     NO.
   1   0.00000   0.00000  -2.00000    0.00000   0.00000   0.00000   0.01000     8        1     8        1
   2   0.00000   0.00000   0.00000    0.00000   0.00000  15.00000   0.01000    10        9    18        2

 TOTAL SEGMENTS USED=   18     NO. SEG. IN A SYMMETRIC CELL=   18     SYMMETRY FLAG=  0


      - MULTIPLE WIRE JUNCTIONS -
JUNCTION    SEGMENTS  (- FOR END 1, + FOR END 2)
 NONE

                        - - - - - - FREQUENCY - - - - - -

                           FREQUENCY= 0.5000E+01 MHZ
                           WAVELENGTH= 0.5996E+02 METERS



                     - - - STRUCTURE IMPEDANCE LOADING - - -

                          THIS STRUCTURE IS NOT LOADED



                         - - - ANTENNA ENVIRONMENT - - -

                              FINITE GROUND.  SOMMERFELD SOLUTION
                              RELATIVE DIELECTRIC CONST.= 10.000
```

CONDUCTIVITY= 0.100E-01 MHOS/METER
COMPLEX DIELECTRIC CONSTANT= 0.10000E+02-0.35951E+02

APPROXIMATE INTEGRATION EMPLOYED FOR SEGMENTS MORE THAN 59.960 METERS APART

- - - MATRIX TIMING - - -

FILL= 3.253 SEC., FACTOR= 0.003 SEC.

- - - ANTENNA INPUT PARAMETERS - - -

TAG NO.	SEG. NO.	VOLTAGE (VOLTS) REAL	IMAG.	CURRENT (AMPS) REAL	IMAG.	IMPEDANCE (OHMS) REAL	IMAG.	ADMITTANCE (MHOS) REAL	IMAG.	POWER (WATTS)
2	9	0.10000E+01	0.00000E+00	0.90158E-02	-0.37068E-02	0.94879E+02	0.39009E+02	0.90158E-02	-0.37068E-02	0.45079E-02

- - - POWER BUDGET - - -

INPUT POWER = 0.4508E-02 WATTS
RADIATED POWER= 0.4508E-02 WATTS
STRUCTURE LOSS= 0.0000E+00 WATTS
NETWORK LOSS = 0.0000E+00 WATTS
EFFICIENCY = 100.00 PERCENT

- - - RADIATION PATTERNS - - -

- - ANGLES - -		- POWER GAINS -			- - - POLARIZATION - - -			- - - E(THETA) - - -		- - - E(PHI) - --,	
THETA DEGREES	PHI DEGREES	VERT. DB	HOR. DB	TOTAL DB	AXIAL RATIO	TILT DEG.	SENSE	MAGNITUDE VOLTS/M	PHASE DEGREES	MAGNITUDE VOLTS/M	PHASE DEGREES
0.00	0.00	-999.99	-999.99	-999.99	0.00000	0.00		0.00000E+00	0.00	0.00000E+00	0.00
5.00	0.00	-23.58	-999.99	-23.58	0.00000	0.00	LINEAR	0.34426E-01	65.98	0.00000E+00	0.00
10.00	0.00	-17.55	-999.99	-17.55	0.00000	0.00	LINEAR	0.68913E-01	65.91	0.00000E+00	0.00
15.00	0.00	-14.02	-999.99	-14.02	0.00000	0.00	LINEAR	0.10349E+00	65.78	0.00000E+00	0.00
20.00	0.00	-11.51	-999.99	-11.51	0.00000	0.00	LINEAR	0.13813E+00	65.60	0.00000E+00	0.00
25.00	0.00	-9.57	-999.99	-9.57	0.00000	0.00	LINEAR	0.17270E+00	65.37	0.00000E+00	0.00
30.00	0.00	-8.00	-999.99	-8.00	0.00000	0.00	LINEAR	0.20695E+00	65.08	0.00000E+00	0.00
35.00	0.00	-6.70	-999.99	-6.70	0.00000	0.00	LINEAR	0.24051E+00	64.72	0.00000E+00	0.00
40.00	0.00	-5.60	-999.99	-5.60	0.00000	0.00	LINEAR	0.27279E+00	64.29	0.00000E+00	0.00
45.00	0.00	-4.69	-999.99	-4.69	0.00000	0.00	LINEAR	0.30302E+00	63.77	0.00000E+00	0.00
50.00	0.00	-3.94	-999.99	-3.94	0.00000	0.00	LINEAR	0.33021E+00	63.15	0.00000E+00	0.00
55.00	0.00	-3.36	-999.99	-3.36	0.00000	0.00	LINEAR	0.35306E+00	62.38	0.00000E+00	0.00
60.00	0.00	-2.96	-999.99	-2.96	0.00000	0.00	LINEAR	0.36990E+00	61.41	0.00000E+00	0.00
65.00	0.00	-2.76	-999.99	-2.76	0.00000	0.00	LINEAR	0.37846E+00	60.15	0.00000E+00	0.00
70.00	0.00	-2.83	-999.99	-2.83	0.00000	0.00	LINEAR	0.37544E+00	58.45	0.00000E+00	0.00
75.00	0.00	-3.30	-999.99	-3.30	0.00000	0.00	LINEAR	0.35548E+00	56.03	0.00000E+00	0.00
80.00	0.00	-4.54	-999.99	-4.54	0.00000	0.00	LINEAR	0.30833E+00	52.32	0.00000E+00	0.00

85.00	0.00	-7.84	-999.99	-7.84	0.00000	0.00	LINEAR	0.21079E+00	46.00	0.00000E+00	0.00
90.00	0.00	-999.99	-999.99	-999.99	0.00000	0.00		0.00000E+00	0.00	0.00000E+00	0.00
0.00	90.00	-999.99	-999.99	-999.99	0.00000	0.00		0.00000E+00	0.00	0.00000E+00	0.00
5.00	90.00	-23.58	-999.99	-23.58	0.00000	0.00	LINEAR	0.34426E-01	65.98	0.00000E+00	0.00
10.00	90.00	-17.55	-999.99	-17.55	0.00000	0.00	LINEAR	0.68913E-01	65.91	0.00000E+00	0.00
15.00	90.00	-14.02	-999.99	-14.02	0.00000	0.00	LINEAR	0.10349E+00	65.78	0.00000E+00	0.00
20.00	90.00	-11.51	-999.99	-11.51	0.00000	0.00	LINEAR	0.13813E+00	65.60	0.00000E+00	0.00
25.00	90.00	-9.57	-999.99	-9.57	0.00000	0.00	LINEAR	0.17270E+00	65.37	0.00000E+00	0.00
30.00	90.00	-8.00	-999.99	-8.00	0.00000	0.00	LINEAR	0.20695E+00	65.08	0.00000E+00	0.00
35.00	90.00	-6.70	-999.99	-6.70	0.00000	0.00	LINEAR	0.24051E+00	64.72	0.00000E+00	0.00
40.00	90.00	-5.60	-999.99	-5.60	0.00000	0.00	LINEAR	0.27279E+00	64.29	0.00000E+00	0.00
45.00	90.00	-4.69	-999.99	-4.69	0.00000	0.00	LINEAR	0.30302E+00	63.77	0.00000E+00	0.00
50.00	90.00	-3.94	-999.99	-3.94	0.00000	0.00	LINEAR	0.33021E+00	63.15	0.00000E+00	0.00
55.00	90.00	-3.36	-999.99	-3.36	0.00000	0.00	LINEAR	0.35306E+00	62.38	0.00000E+00	0.00
60.00	90.00	-2.96	-999.99	-2.96	0.00000	0.00	LINEAR	0.36990E+00	61.41	0.00000E+00	0.00
65.00	90.00	-2.76	-999.99	-2.76	0.00000	0.00	LINEAR	0.37846E+00	60.15	0.00000E+00	0.00
70.00	90.00	-2.83	-999.99	-2.83	0.00000	0.00	LINEAR	0.37544E+00	58.45	0.00000E+00	0.00
75.00	90.00	-3.30	-999.99	-3.30	0.00000	0.00	LINEAR	0.35548E+00	56.03	0.00000E+00	0.00
80.00	90.00	-4.54	-999.99	-4.54	0.00000	0.00	LINEAR	0.30833E+00	52.32	0.00000E+00	0.00
85.00	90.00	-7.84	-999.99	-7.84	0.00000	0.00	LINEAR	0.21079E+00	46.00	0.00000E+00	0.00
90.00	90.00	-999.99	-999.99	-999.99	0.00000	0.00		0.00000E+00	0.00	0.00000E+00	0.00

AVERAGE POWER GAIN= 0.32810E+00 SOLID ANGLE USED IN AVERAGING=(0.5000)*PI STERADIANS.

***** DATA CARD NO. 6 NE 0 1 1 21 0.50000E+04 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.100
00E+02

- - - NEAR ELECTRIC FIELDS - - -

- LOCATION -			- EX -		- EY -		- EZ -		- PEAK FIELDS -
X METERS	Y METERS	Z METERS	MAGNITUDE VOLTS/M	PHASE DEGREES	MAGNITUDE VOLTS/M	PHASE DEGREES	MAGNITUDE VOLTS/M	PHASE DEGREES	MAGNITUDE VOLTS/M
5000.0000	0.0000	0.0000	0.1058E-04	140.80	0.0000E+00	0.00	0.6463E-04	103.53	0.6518E-04
5000.0000	0.0000	10.0000	0.1013E-04	141.10	0.0000E+00	0.00	0.6313E-04	103.16	0.6364E-04
5000.0000	0.0000	20.0000	0.9707E-05	141.29	0.0000E+00	0.00	0.6176E-04	102.65	0.6223E-04
5000.0000	0.0000	30.0000	0.9300E-05	141.40	0.0000E+00	0.00	0.6051E-04	102.00	0.6093E-04
5000.0000	0.0000	40.0000	0.8912E-05	141.41	0.0000E+00	0.00	0.5936E-04	101.21	0.5975E-04
5000.0000	0.0000	50.0000	0.8541E-05	141.34	0.0000E+00	0.00	0.5831E-04	100.29	0.5867E-04
5000.0000	0.0000	60.0000	0.8186E-05	141.19	0.0000E+00	0.00	0.5737E-04	99.24	0.5769E-04
5000.0000	0.0000	70.0000	0.7846E-05	140.96	0.0000E+00	0.00	0.5651E-04	98.07	0.5680E-04
5000.0000	0.0000	80.0000	0.7520E-05	140.66	0.0000E+00	0.00	0.5573E-04	96.77	0.5600E-04
5000.0000	0.0000	90.0000	0.7208E-05	140.28	0.0000E+00	0.00	0.5504E-04	95.35	0.5528E-04
5000.0000	0.0000	100.0000	0.6909E-05	139.85	0.0000E+00	0.00	0.5441E-04	93.80	0.5463E-04
5000.0000	0.0000	110.0000	0.6622E-05	139.35	0.0000E+00	0.00	0.5386E-04	92.14	0.5405E-04
5000.0000	0.0000	120.0000	0.6346E-05	138.80	0.0000E+00	0.00	0.5337E-04	90.36	0.5354E-04
5000.0000	0.0000	130.0000	0.6082E-05	138.21	0.0000E+00	0.00	0.5294E-04	88.47	0.5309E-04
5000.0000	0.0000	140.0000	0.5828E-05	137.57	0.0000E+00	0.00	0.5257E-04	86.47	0.5269E-04
5000.0000	0.0000	150.0000	0.5585E-05	136.90	0.0000E+00	0.00	0.5224E-04	84.35	0.5236E-04
5000.0000	0.0000	160.0000	0.5352E-05	136.21	0.0000E+00	0.00	0.5197E-04	82.12	0.5207E-04
5000.0000	0.0000	170.0000	0.5129E-05	135.50	0.0000E+00	0.00	0.5174E-04	79.79	0.5182E-04
5000.0000	0.0000	180.0000	0.4916E-05	134.78	0.0000E+00	0.00	0.5155E-04	77.34	0.5162E-04

```
   5000.0000     0.0000  190.0000     0.4712E-05   134.06    0.0000E+00     0.00   0.5140E-04    74.79       0.5146E-04
   5000.0000     0.0000  200.0000     0.4518E-05   133.35    0.0000E+00     0.00   0.5129E-04    72.13       0.5134E-04


 ***** DATA CARD NO.  7   EN   0     0     0     0  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.000
00E+00

 RUN TIME =     4.990

 INPUT DATA FILE

 CM TEST G2
 CM
 CM MONOPOLE ANTENNA ON A GROUND STAKE
 CE
 GW 1,8, 0,0,-2, 0,0,0, .01
 GW 2,10, 0,0,0, 0,0,15, .01
 GP
 GE
 GN 2,0,0,0, 10,.01
 FR 0,0,0,0, 5
 PT -1
 EX 0,2,1,0, 1
 RP 0,19,2,1001, 0,0,5,90
 NE 0,1,1,21, 5000,0,0, 0,0,10
 EN
```

B. NPSROM.OUT (RHOMBIC ANTENNA)

****

NUMERICAL ELECTROMAGNETICS CODE - NPGNEC

****

- - - - COMMENTS - - - -

TEST OF NPSNEC AS ON C DISK 7 FEB 83
RHOMBIC ANTENNA HORIZONTALLY POLARIZED
LEG LENGTH=398.0 FT.
CENTER WIDTH=314.0 FT.
APEX ANGLE=44.0 DEGREES.
HEIGHT ABOVE GROUND=160.0 FT.
GROUND PARAMETERS-EPSILON=80. SIGMA=4. MHOS/M. (SEA WATER)
CONDUCTOR-AWG NO. 10 WIRE DIA.=0.00425 FT.

- - - STRUCTURE SPECIFICATION - - -

COORDINATES MUST BE INPUT IN
METERS OR BE SCALED TO METERS
BEFORE STRUCTURE INPUT IS ENDED

WIRE NO.	X1	Y1	Z1	X2	Y2	Z2	RADIUS	NO. OF SEG.	FIRST SEG.	LAST SEG.	TAG NO.
1	0.00000	0.00000	160.00000	366.08179	157.00000	160.00000	0.00425	40	1	40	1
2	366.08179	157.00000	160.00000	732.16382	0.00000	160.00000	0.00425	40	41	80	2

STRUCTURE REFLECTED ALONG THE AXES Y . TAGS INCREMENTED BY 2
STRUCTURE SCALED BY FACTOR 0.30480

GROUND PLANE SPECIFIED.

WHERE WIRE ENDS TOUCH GROUND, CURRENT WILL BE INTERPOLATED TO IMAGE IN GROUND PLANE.

TOTAL SEGMENTS USED= 160 NO. SEG. IN A SYMMETRIC CELL= 80 SYMMETRY FLAG= 1
STRUCTURE HAS 1 PLANES OF SYMMETRY

- MULTIPLE WIRE JUNCTIONS -
JUNCTION SEGMENTS (- FOR END 1, + FOR END 2)
NONE

- - - - - - FREQUENCY - - - - - -

FREQUENCY= 0.1000E+02 MHZ

WAVELENGTH= 0.2998E+02 METERS

- - - STRUCTURE IMPEDANCE LOADING - - -

LOCATION ITAG	FROM	THRU	RESISTANCE OHMS	INDUCTANCE HENRYS	CAPACITANCE FARADS	IMPEDANCE (OHMS) REAL	IMAGINARY	CONDUCTIVITY MHOS/METER	TYPE
2	40	40	0.3000E+03						SER
4	40	40	0.3000E+03						SER

- - - ANTENNA ENVIRONMENT - - -

FINITE GROUND. REFLECTION COEFFICIENT APPROXIMATION
RELATIVE DIELECTRIC CONST.= 80.000
CONDUCTIVITY= 0.400E+01 MHOS/METER
COMPLEX DIELECTRIC CONSTANT= 0.80000E+02-0.71902E+04

APPROXIMATE INTEGRATION EMPLOYED FOR SEGMENTS MORE THAN 29.980 METERS APART
CP TIME TAKEN FOR FACTORIZATION = 0.20800E+01

- - - MATRIX TIMING - - -

FILL= 11.870 SEC., FACTOR= 2.417 SEC.

MAXIMUM RELATIVE ASYMMETRY OF THE DRIVING POINT ADMITTANCE MATRIX IS 0.819E-06 FOR SEGMENTS 81 AND 1
RMS RELATIVE ASYMMETRY IS 0.819E-06

- - - ANTENNA INPUT PARAMETERS - - -

TAG NO.	SEG. NO.	VOLTAGE (VOLTS) REAL	IMAG.	CURRENT (AMPS) REAL	IMAG.	IMPEDANCE (OHMS) REAL	IMAG.	ADMITTANCE (MHOS) REAL	IMAG.	POWER (WATTS)
1	1	0.50000E+00	0.00000E+00	0.11465E-02	-0.56027E-03	0.35205E+03	0.17204E+03	0.22929E-02	-0.11205E-02	0.28662E-03
3	81	-0.50000E+00	0.00000E+00	-0.11465E-02	0.56027E-03	0.35205E+03	0.17204E+03	0.22929E-02	-0.11205E-02	0.28662E-03

- - - POWER BUDGET - - -

INPUT POWER = 0.5732E-03 WATTS
RADIATED POWER= 0.2882E-03 WATTS
STRUCTURE LOSS= 0.2850E-03 WATTS
NETWORK LOSS = 0.0000E+00 WATTS

EFFICIENCY = 50.27 PERCENT

- - - RADIATION PATTERNS - - -

- - ANGLES - -		- POWER GAINS -			- - - POLARIZATION - - -			- - - E(THETA) - - -		- - - E(PHI) - - -,	
THETA DEGREES	PHI DEGREES	VERT. DB	HOR. DB	TOTAL DB	AXIAL RATIO	TILT DEG.	SENSE	MAGNITUDE VOLTS/M	PHASE DEGREES	MAGNITUDE VOLTS/M	PHASE DEGREES
90.00	0.00	-999.99	-77.44	-77.44	0.00000	-90.00	LINEAR	0.79825E-11	-28.27	0.24893E-04	65.20
85.00	0.00	-100.97	15.87	15.87	0.00000	-90.00	LINEAR	0.16571E-05	58.61	0.11523E+01	-32.92
80.00	0.00	-96.10	17.95	17.95	0.00000	-90.00	LINEAR	0.29043E-05	53.21	0.14646E+01	-47.05
75.00	0.00	-125.90	11.26	11.26	0.00000	90.00	LINEAR	0.94010E-07	11.85	0.67787E+00	-70.41
70.00	0.00	-125.65	6.97	6.97	0.00000	-90.00	LINEAR	0.96684E-07	-27.76	0.41361E+00	76.27
65.00	0.00	-106.14	11.33	11.33	0.00000	-90.00	LINEAR	0.91386E-06	-58.11	0.68304E+00	35.75
60.00	0.00	-106.11	2.02	2.02	0.00000	90.00	LINEAR	0.91704E-06	-97.15	0.23406E+00	-11.29
55.00	0.00	-120.44	-22.22	-22.22	0.00000	90.00	LINEAR	0.17633E-06	-81.79	0.14364E-01	-114.96
50.00	0.00	-111.78	-9.30	-9.30	0.00000	-90.00	LINEAR	0.47764E-06	102.97	0.63573E-01	1.52
45.00	0.00	-108.83	5.67	5.67	0.00000	-90.00	LINEAR	0.67103E-06	55.56	0.35627E+00	-62.49
40.00	0.00	-101.72	4.16	4.16	0.00000	-90.00	LINEAR	0.15206E-05	130.10	0.29945E+00	-136.77
35.00	0.00	-107.70	-15.81	-15.81	0.00000	-90.00	LINEAR	0.76383E-06	64.64	0.30049E-01	161.03
30.00	0.00	-103.61	-8.90	-8.90	0.00000	-90.00	LINEAR	0.12229E-05	103.91	0.66508E-01	4.92
25.00	0.00	-121.15	-13.08	-13.08	0.00000	-90.00	LINEAR	0.16245E-06	105.62	0.41128E-01	-79.92
20.00	0.00	-113.14	-21.47	-21.47	0.00000	-90.00	LINEAR	0.40836E-06	-110.08	0.15655E-01	9.80
15.00	0.00	-106.30	-27.33	-27.33	0.00000	-90.00	LINEAR	0.89714E-06	-52.10	0.79728E-02	-157.16
10.00	0.00	-106.94	-4.71	-4.71	0.00000	-90.00	LINEAR	0.83347E-06	-118.38	0.10778E+00	123.70
5.00	0.00	-101.44	-9.37	-9.37	0.00000	-90.00	LINEAR	0.15708E-05	-76.26	0.63025E-01	30.43
0.00	0.00	-108.23	-29.91	-29.91	0.00000	-90.00	LINEAR	0.71890E-06	-52.52	0.59252E-02	-179.31
-5.00	0.00	-107.94	-6.52	-6.52	0.00000	-90.00	LINEAR	0.74318E-06	-122.10	0.87489E-01	131.58
-10.00	0.00	-107.52	-12.18	-12.18	0.00000	-90.00	LINEAR	0.78036E-06	-64.52	0.45600E-01	43.21
-15.00	0.00	-115.56	-36.52	-36.52	0.00034	-89.99	RIGHT	0.30922E-06	-71.90	0.27668E-02	124.20
-20.00	0.00	-120.33	-21.15	-21.15	0.00000	-90.00	LINEAR	0.17853E-06	-83.37	0.16233E-01	146.55
-25.00	0.00	-121.67	-23.63	-23.63	0.00000	-90.00	LINEAR	0.15295E-06	137.46	0.12205E-01	-99.44
-30.00	0.00	-113.51	-22.33	-22.33	0.00000	-90.00	LINEAR	0.39157E-06	105.39	0.14172E-01	-116.58
-35.00	0.00	-109.51	-17.10	-17.10	0.00000	-90.00	LINEAR	0.62038E-06	122.22	0.25881E-01	-0.52
-40.00	0.00	-110.22	-8.78	-8.78	0.00000	-90.00	LINEAR	0.57156E-06	119.48	0.67463E-01	-46.45
-45.00	0.00	-112.00	-10.77	-10.77	0.00000	-90.00	LINEAR	0.46563E-06	130.95	0.53676E-01	-74.47
-50.00	0.00	-118.69	-23.25	-23.25	0.00000	-90.00	LINEAR	0.21553E-06	133.23	0.12757E-01	-114.31
-55.00	0.00	-121.36	-44.44	-44.44	0.00000	-90.00	LINEAR	0.15853E-06	-81.78	0.11114E-02	-177.81
-60.00	0.00	-113.32	-21.18	-21.18	0.00000	-90.00	LINEAR	0.40012E-06	0.63	0.16183E-01	-151.93
-65.00	0.00	-108.25	-8.59	-8.59	0.00000	-90.00	LINEAR	0.71738E-06	-30.96	0.68925E-01	-132.64
-70.00	0.00	-124.53	-10.35	-10.35	0.00000	-90.00	LINEAR	0.11003E-06	-45.55	0.56314E-01	-163.54
-75.00	0.00	-133.68	-4.83	-4.83	0.00000	-90.00	LINEAR	0.38389E-07	-112.01	0.10634E+00	-12.53
-80.00	0.00	-120.55	2.51	2.51	0.00000	90.00	LINEAR	0.17395E-06	-123.81	0.24741E+00	-35.39
-85.00	0.00	-122.96	0.74	0.74	0.00000	-90.00	LINEAR	0.13190E-06	-144.96	0.20189E+00	-49.45
-90.00	0.00	-999.99	-94.91	-94.91	0.00000	-90.00	LINEAR	0.50536E-12	118.38	0.33319E-05	17.08

- - - - NORMALIZED GAIN - - - -

HORIZONTAL GAIN
NORMALIZATION FACTOR = 17.95 DB

- - ANGLES - -		GAIN	- - ANGLES - -		GAIN	- - ANGLES - -		GAIN
THETA DEGREES	PHI DEGREES	DB	THETA DEGREES	PHI DEGREES	DB	THETA DEGREES	PHI DEGREES	DB

90.00	0.00	-95.39	25.00	0.00	-31.03	-35.00	0.00	-35.05
85.00	0.00	-2.08	20.00	0.00	-39.42	-40.00	0.00	-26.73
80.00	0.00	0.00	15.00	0.00	-45.28	-45.00	0.00	-28.72
75.00	0.00	-6.69	10.00	0.00	-22.66	-50.00	0.00	-41.20
70.00	0.00	-10.98	5.00	0.00	-27.32	-55.00	0.00	-62.40
65.00	0.00	-6.63	0.00	0.00	-47.86	-60.00	0.00	-39.13
60.00	0.00	-15.93	-5.00	0.00	-24.48	-65.00	0.00	-26.55
55.00	0.00	-40.17	-10.00	0.00	-30.14	-70.00	0.00	-28.30
50.00	0.00	-27.25	-15.00	0.00	-54.47	-75.00	0.00	-22.78
45.00	0.00	-12.28	-20.00	0.00	-39.11	-80.00	0.00	-15.45
40.00	0.00	-13.79	-25.00	0.00	-41.58	-85.00	0.00	-17.21
35.00	0.00	-33.76	-30.00	0.00	-40.29	-90.00	0.00	-112.86
30.00	0.00	-26.86						

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***** DATA CARD NO.  9   EN   0     0     0     0 0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.000
00E+00

 RUN TIME =     17.983

 INPUT DATA FILE

 CM   TEST OF NPSNEC AS ON C DISK 7 FEB 83
 CM RHOMBIC ANTENNA HORIZONTALLY POLARIZED
 CM LEG LENGTH=398.0 FT.
 CM CENTER WIDTH=314.0 FT.
 CM APEX ANGLE=44.0 DEGREES.
 CM HEIGHT ABOVE GROUND=160.0 FT.
 CM GROUND PARAMETERS-EPSILON=80. SIGMA=4. MHOS/M. (SEA WATER)
 CE CONDUCTOR-AWG NO. 10 WIRE DIA.=0.00425 FT.
 GW1,40,0.0,0.0,160.0,366.082,157.0,160.0,0.00425
 GW2,40,366.082,157.0,160.0,732.164,0.0,160.0,0.00425
 GX2,010
 GS0,0,0.304801
 GP
 GE1
 FR0,0,0,0,10.0
 GN0,0,0,0,80.0,4.0
 LD0,2,40,40,300.0
 LD0,4,40,40,300.0
 PT -1
 EX0,1,1,0,0.5
 EX0,3,1,10,-0.5
 RP0,37,1,1401,90.0,0.0,-5.0,0.0
 EN
```

C. NPSDP49.OUT (49 SEGMENT CENTER FED DIPOLE)

```
              ********************************************

               NUMERICAL ELECTROMAGNETICS CODE - DNPGNEC

              ********************************************


                      - - - - COMMENTS - - - -


        DIPOLE WITH 49 SEGEMENTS


                - - - STRUCTURE SPECIFICATION - - -

                   COORDINATES MUST BE INPUT IN
                   METERS OR BE SCALED TO METERS
                   BEFORE STRUCTURE INPUT IS ENDED


WIRE                                                                    NO. OF   FIRST  LAST    TAG
NO.      X1        Y1        Z1         X2        Y2        Z2      RADIUS   SEG.    SEG.   SEG.    NO.
  1   0.00000   0.00000   0.00000    0.00000   0.00000   0.50000   0.00001    49       1    49       1

 TOTAL SEGMENTS USED=  49     NO. SEG. IN A SYMMETRIC CELL=  49     SYMMETRY FLAG=  0


      - MULTIPLE WIRE JUNCTIONS -
JUNCTION    SEGMENTS  (- FOR END 1, + FOR END 2)
 NONE

                 - - - - - - FREQUENCY - - - - - -

                    FREQUENCY= 0.2998E+03 MHZ
                    WAVELENGTH= 0.1000E+01 METERS


               - - - STRUCTURE IMPEDANCE LOADING - - -

                  THIS STRUCTURE IS NOT LOADED



                 - - - ANTENNA ENVIRONMENT - - -

                         FREE SPACE


      APPROXIMATE INTEGRATION EMPLOYED FOR SEGMENTS MORE THAN   1.000 METERS APART
```

```
                    - - - MATRIX TIMING - - -

             FILL=    3.013 SEC.,  FACTOR=    0.243 SEC.


                              - - - ANTENNA INPUT PARAMETERS - - -

  TAG  SEG.   VOLTAGE (VOLTS)        CURRENT (AMPS)        IMPEDANCE (OHMS)       ADMITTANCE (MHOS)      POWER
  NO.  NO.    REAL       IMAG.       REAL       IMAG.      REAL       IMAG.       REAL       IMAG.      (WATTS)
   1    25 0.10000E+01 0.00000E+00 0.96806E-02-0.55277E-02 0.77900E+02 0.44481E+02 0.96806E-02-0.55277E-02 0.48403E-02


                             - - - POWER BUDGET - - -

                               INPUT POWER   = 0.4840E-02 WATTS
                               RADIATED POWER= 0.4840E-02 WATTS
                               STRUCTURE LOSS= 0.0000E+00 WATTS
                               NETWORK LOSS  = 0.0000E+00 WATTS
                               EFFICIENCY    = 100.00 PERCENT


 ***** DATA CARD NO.  3   EN   0     0     0     0  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.000
00E+00

 RUN TIME =      3.460

INPUT DATA FILE

 CE  DIPOLE WITH 49 SEGEMENTS
 GW 1,49, 0,0,0, 0,0,.5, .00001
 GP
 GE
 EX 0,1,25
 XQ
 EN
```

LIST OF REFERENCES

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Thesis
O3438 O'Hara
c.1 Implementation and
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